The Welding Engineer

Vol. II. Chicago 608 S. Dearborn St. MAY, 1917 $2.00 per year in U. S. $2.50 per year abroad No. 5

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Acetylene Service

Prompt—Universal—Perpetual

NO matter what use you make of acetylene, or what apparatus you now employ, Prest-O-Lite Acetylene Service offers you real co-operation of a helpful character.

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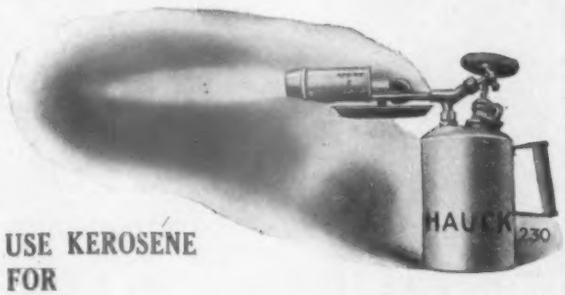

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Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

ACETYLENE (Compressed in Cylinders)
Commercial Acetylene Welding Co.
The Prest-O-Lite Co., Inc.
Universal Oxygen Co.

ACETYLENE CYLINDERS
Janney-Steinmetz Co.

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Oxweld Acetylene Co.
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Bermo Supply Co.
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Superior Oxy-Acetylene Mach. Co.
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Universal Oxygen Co.
Vulcan Process Co.

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The Imperial Brass Mfg. Co.
Hauck Mfg. Co.
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The Prest-O-Lite Co.
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Universal Oxygen Co.
Vulcan Process Co.

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Universal Oxygen Co.

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ASBESTOS SHEET PAPER
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Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
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BLOW TORCHES (Acetylene)
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Buffalo Dental Mfg. Co.
Hauck Mfg. Co.
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Vulcan Process Co.

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The Welding Engineer
P. F. Willis.

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Bermo Supply Co.
Davis-Bournonville Co.
The Imperial Brass Mfg. Co.
United States Welding Co.
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The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
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Vulcan Process Co.

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Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Union Carbide Sales Co.

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CARBO-HYDROGEN
Carbo-Hydrogen Co. of America

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Bermo Supply Co.
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The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
Messer & Co.
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The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Mach. Co.
Universal Oxygen Co.
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Hauck Mfg. Co.
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Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

CRANES (Portable)

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Universal Oxygen Co.
Vulcan Process Co.

FILLER RODS (Aluminum)
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Bierman-Everett Fdy. Co.
Hauck Mfg. Co.
United States Welding Co.
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Vulcan Process Co.

FILLER RODS (Swedish Iron)
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Davis-Bournonville Co.
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The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
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Steel Sales Corp.
Universal Oxygen Co.
Vulcan Process Co.

FILLER RODS (Tobin Bronze)
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Davis-Bournonville Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
Steel Sales Corp.
Vulcan Process Co.
United States Welding Co.
Universal Oxygen Co.

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Bermo Supply Co.
Bierman-Everett Fdy. Co.
Davis-Bournonville Co.
Hauck Mfg. Co.
The Imperial Brass Mfg. Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co.
Steel Sales Corp.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Hauck Mfg. Co.
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Superior Oxy-Acetylene Machine Co.

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Superior Oxy-Acetylene Machine Co.
Universal Oxygen Co.
Westinghouse Electric & Mfg. Co.
Vulcan Process Co.

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Vulcan Process Co.

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Carbo-Hydrogen Co. of America.
Chicago Eye Shield Co.
F. A. Hardy & Co.
Vulcan Process Co.

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Hauck Mfg. Co.

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Carbo-Hydrogen Co. of America

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Bermo Supply Co.
Buffalo Dental Mfg. Co.
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Imperial Brass Mfg. Co.
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Universal Oxygen Co.
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Hauck Mfg. Co.
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Vulcan Process Co.

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Bermo Supply Co.
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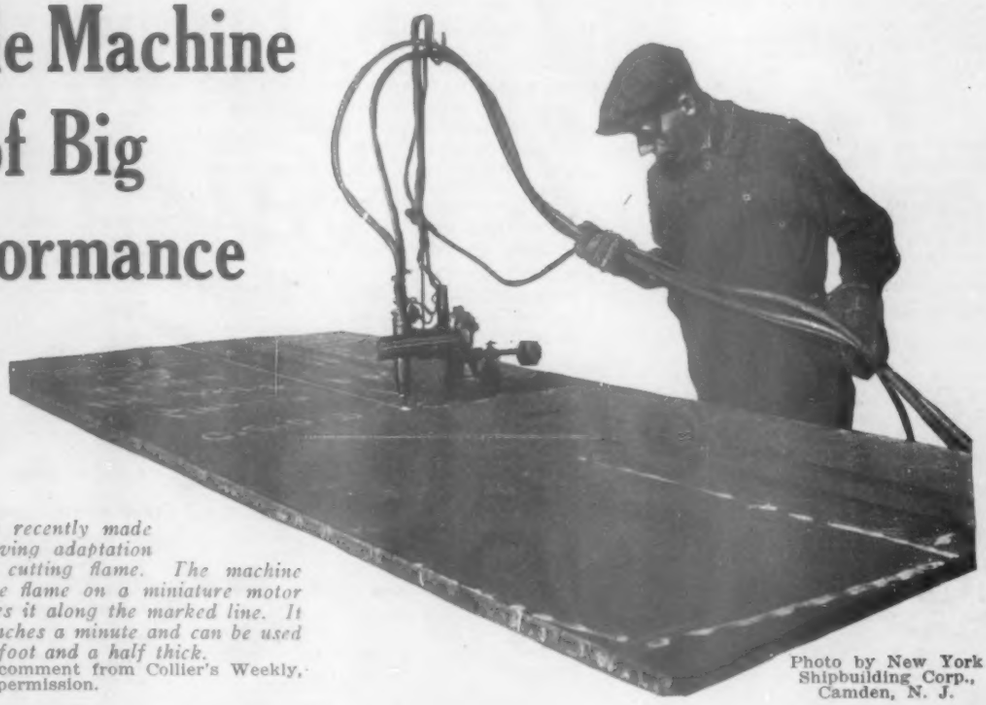
Superior Oxy-Acetylene Machine Co.
Vulcan Process Co.

A Little Machine of Big Performance



Shipbuilders have recently made a special labor-saving adaptation of the acetylene cutting flame. The machine shown mounts the flame on a miniature motor truck which carries it along the marked line. It will cut thirteen inches a minute and can be used on armor plate a foot and a half thick.
—Illustration and comment from Collier's Weekly, April 7, 1917, by permission.

Photo by New York Shipbuilding Corp., Camden, N. J.

It is the Radiagraph

Cutting Steel Plate with the Oxy-Acetylene Torch in the New York Shipbuilding Yards, Camden

The Radiagraph is one of the exclusive developments by the Davis-Bournonville Company for mechanical cutting of steel plate with the oxy-acetylene or oxy-hydrogen flame. With the Radiagraph, steel plate and armor plate from 1 to 18 inches thick is smoothly cut at speed varying from 4 to 18 lineal inches a minute, according to thickness of steel. With the Oxygraph, another exclusive development, steel plate from 1 to 18 inches thick is readily cut in any direction, according to pattern or tracing, following straight or irregular lines, curves or sharp angles, with equal facility. Extensively used by Bethlehem Steel Co., Youngstown Sheet and Tube Co., Carnegie Steel Co., E. W. Bliss Co., Lukens Iron and Steel Co., New York Shipbuilding Corp., Newport News Shipbuilding and Dry Dock Co., General Electric Co., Westinghouse Electric and Mfg. Co., Canadian Westinghouse Co., American Locomotive Co., Canadian Locomotive Co., Lima Locomotive Co., Marion Steam Shovel Co., Camden Forge Co., Pennsylvania Shipbuilding Co., United States Navy Yards at Boston, Brooklyn, Philadelphia, Norfolk, Washington, San Francisco, Seattle, and in numerous other metal working plants.

The Davis-Bournonville Company has developed the widest range of equipment made for utilizing the oxy-acetylene and oxy-hydrogen processes of welding and cutting, and *"Davis Apparatus" Leads the World for Range, Efficiency and Number of Users.*

Fully protected by broad basic patents, Nos. 1,059,329 and 1,118,183, covering cutting torch and mechanical means for supporting and propelling same at uniform and determined speed. Manufactured and sold only by

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San Francisco,
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Superior Oxy-Acetylene Mach. Co.
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The Linde Air Products Co.
Swift & Co.
Universal Oxygen Co.
Vulcan Process Co.

OXYGEN CYLINDERS
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U. S. Gauge Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Oxweld Railroad Service Co.

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Bermo Supply Co.
The Bishop-Babcock-Becker Co.
Davis-Bournonville Co.
Hauck Mfg. Co.
The Imperial Brass Mfg. Co.
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Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
The Prest-O-Lite Co., Inc.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Carbo-Hydrogen Co. of America

REGULATING VALVES (Hydrogen)
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Bermo Supply Co.
The Bishop-Babcock-Becker Co.
The Prest-O-Lite Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Superior Oxy-Acetylene Machine Co.
Universal Oxygen Co.
Vulcan Process Co.

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Superior Oxy-Acetylene Machine Co.

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THERMIT WELDING
Goldschmidt-Thermit Co.

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Hauck Mfg. Co.
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The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Westinghouse Electric & Mfg. Co.
Vulcan Process Co.

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Davis-Bournonville Co.
General Welding & Eq. Co.
The Harris Calorific Co.
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The Imperial Brass Mfg. Co.
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Welding Supply Co.
K-G Welding & Cutting Co.
The Alexander Milburn Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Machine Co.
The Thermalene Co.
United States Welding Co.
Universal Oxygen Co.
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Davis-Bournonville Co.
Ideal Bronze Co.
General Welding & Eq. Co.
The Harris Calorific Co.
Messer & Co.
Welding Supply Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
The Alexander Milburn Co.
Oxweld Acetylene Co.
The Prest-O-Lite Co., Inc.
Superior Oxy-Acetylene Machine Co.
The Thermalene Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

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Messer & Co.
Welding Supply Co.
General Welding & Eq. Co.
Ideal Bronze Co.
The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Alexander Milburn Co.
The Imperial Brass Mfg. Co.
Vulcan Process Co.
Oxweld Acetylene Co.
Superior Oxy-Acetylene Machine Co.
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Bermo Supply Co.
Messer & Co.
Welding Supply Co.
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Buffalo Dental Mfg. Co.
Davis-Bournonville Co.
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The Harris Calorific Co.
Henderson-Willis Welding & Cutting Co.
The Imperial Brass Mfg. Co.
The Alexander Milburn Co.
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United States Welding Co.
Universal Oxygen Co.

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The Harris Calorific Co.
Superior Oxy-Acetylene Machine Co.
Vulcan Process Co.

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M. Desmond Mfg. Co.
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Oxweld Acetylene Co.
The Prest-O-Lite Co.
Superior Oxy-Acetylene Machine Co.
United States Welding Co.
Universal Oxygen Co.
Vulcan Process Co.

VALVES (For Oxygen Cylinders)
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Universal Oxygen Co.
Vulcan Process Co.

WELDING (Electric Resistance-Custom Work)
Thomson Electric Welding Co.

WELDERS' GOGGLES
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Chicago Eye Shield Co.
F. A. Hardy Co.
Vulcan Process Co.

WELDING (Oxygen for)
The Linde Air Products Co.
Universal Oxygen Co.
Vulcan Process Co.

WELDING RODS
Bierman-Everett Fdy. Co.
Vulcan Process Co.

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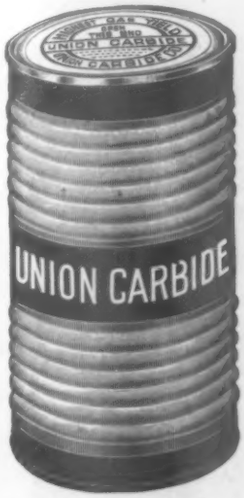

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"World's Best Quality—Highest Gas Yield"

For Oxy-Acetylene Welding Plants

Contractors' Flare Lights, Torches and Private and Municipal Lighting Plants

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Union Carbide in the Generator sizes above listed will be shipped direct to consumers from a **Union Carbide Sales Co.** warehouse at any one of the following points where large stocks are kept on hand:

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ARKANSAS
Fort Smith—109-123 So. Ninth St.
CALIFORNIA
Eureka—109 Second St.
Fresno—932 H St.
Los Angeles—639 Gibbon St.
Sacramento—1523-31 Front St.
San Diego—326-336 Fifth St.
San Francisco—Kohl Building.
COLORADO
Denver—Nineteenth and Wazee Sts.
Victor—Third and Diamond Sts.
CONNECTICUT
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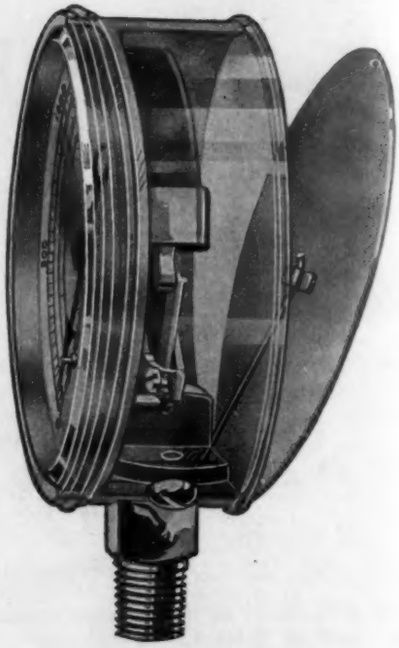

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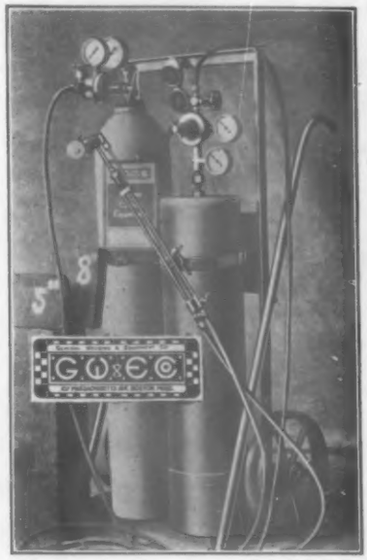

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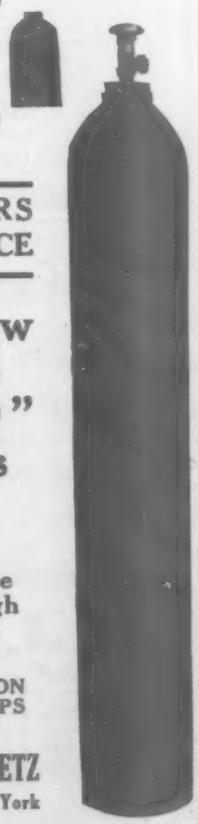

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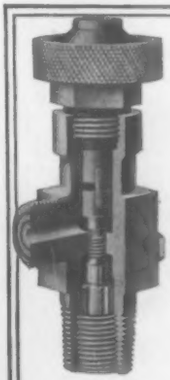

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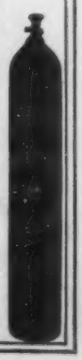

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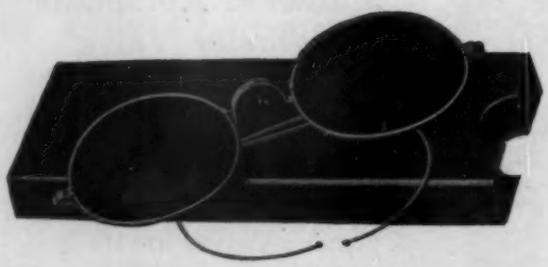

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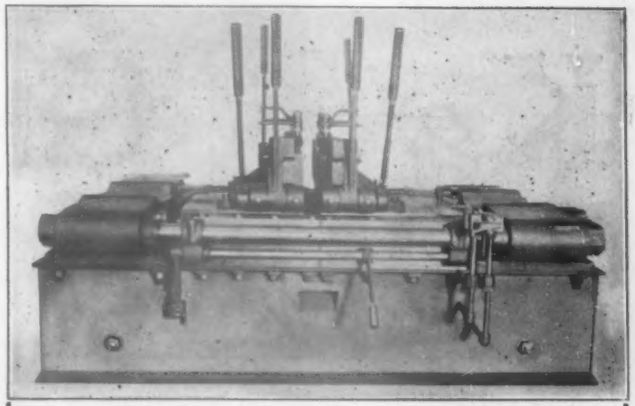

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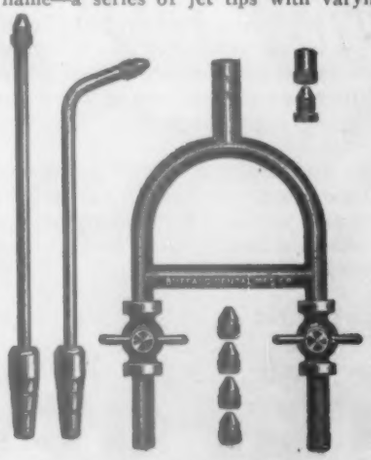

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REMINISCENCES *of a* WELDER

VI—Jottings from the Notebook

WHEN the editor and I first talked over these reminiscences, I thought it would be a very simple matter to write at least six; yet when it came time to write the sixth and last of the series, the choosing of one particular incident of the old days which would be interesting to you readers seemed impossible; hence the title. It has just dawned upon me that I am undoubtedly a good deal better welder than I am a Reminiscence teller—a fact with which all of you have probably been familiar since the first of the series—and my hand is up in the air in the familiar "Never Again" position when this sixth spasm is completed. Just what punishment is in store for me for inflicting these tales upon those who never wronged me I know not, but without pleading extenuating circumstances, I can only say that the editor urged them, that I really tried to drive home something worth while, but that I'll never do it again.

Did you ever do a job for a big concern, fall down on it and then keep hearing from dozens of sources that that particular big concern had tried oxy-acetylene welding and found it no good? Of course, you have, that is, if you have been a welder for any length of time at all. It is a pity that the system has to stand the brunt of all the poor workmanship, but as a rule, the process is judged by results. Let me tell you a story of a man who judged differently; at least who had a poor job done and yet enthused over the process.

This man specialized in big steam pipe and supplies. He had tried oxy-acetylene welding in the very early days with one of the self-contained equipments; one generating both oxygen and acetylene. Due to the imperfectness of the equipment, and as well perhaps to lack of trained labor, his results were disappointing and oxy-acetylene was thought useless for pipe and header welding. I had a hard job later convincing this man that I could handle his work, but after four or five visits, he agreed to give us a trial and we went to the work prepared to show him. And we did. For quite awhile we sent one of two picked men for this kind of work—men who could do overhead steel welding for instance, and make it seem as if this was the only way to weld and who could be depended upon to make a sound weld without watching. Often I did not know what was welded, as we billed this particular work on an hour and gas basis and the owner of the pipe shop furnished all necessary aids.

There came a day when he wanted some welding work done and our own shop was jammed with rush repair work. we couldn't send either of the two men who had been handling the work, but we did have a new man, one who had been with us a couple of weeks welding ten-gauge material for special construction work. He had had a lot of experience on light metal work and was a fast, "pretty" welder, so we sent him to the job. I don't remember how long he was on the work, but I do remember that the pipe manufacturer talked with me on the telephone and said how well pleased he was with this new man; that he was much faster than either of the two regulars; and that the weld had a fine appearance.

A couple of weeks later a telephone message asked that I come right over to his plant. Arriving there, he took me into one of the shops and pointed and when my eyes followed his finger I had one of those "sick to my tummy" sensations most of us are familiar with. The job which our quick welder had worked upon was a steam header, about 30 inches in diameter with head and bottom welded on. The material was $\frac{5}{16}$ths. One end had blown out while it was in operation in the plant under 200 pounds steam pressure. Fortunately there was a heavy post directly in front of it which stood up under the impact and so perhaps saved the life of the engineer. This end was twisted and bent as if it were a piece of paper. I didn't say anything; I couldn't; but I did walk over to the tank and begin examining it. The weld was almost exactly $\frac{1}{16}$ inch all the way round, less than one-third the thickness of the metal, yet it had withstood the pressure test before being shipped. The owner of the plant, strange to say, did not place the burden of this poor weld upon me. He thought that he should have himself seen the defects as the weld was being made and he absolved me from all blame. (Gee, but it's great to meet a man of that caliber, isn't it?) And then he made his surprising statement. "This," said he, "is the finest example of the strength of an oxy-acetylene welded joint I have ever seen. Just think, that $\frac{1}{16}$ths inch of metal held 200 pounds steam pressure for two weeks before it let go. Just think of the strength of that bond if it had been properly made. I'll never question the strength of a weld again."

Perhaps you'll all say that I should have known the qualifications of the welder who did this job and I agree, but we learn slowly and perhaps that's one of the reasons for these Reminscences—so that you can learn without paying such a heavy price. This welder was not wholly to blame. His previous experience had been wholly on piece work. He had never learned to make a really good weld; just a good-looking one—something that would pass the inspector's eye and let him make a day's pay. There's a little moral there if anyone wants to apply it.

When did you learn that steel could be welded in a vertical or overhead position? I recall that it was sometime after I started to weld before I found it out and it was all the fault of one of those little Maxwell runabouts. You remember them don't you, two cylinder, gear shift on the seat, buggy-looking affairs, but an almighty good little automobile? This one had a broken frame (as quite a few of them did), and it came to the shop with the body off. It was our first frame welding job and every time I think about it, it brings a smile. What would you do with a broken frame, if you had advertised to weld and guarantee anything that came along? Would you take out the motor and strip the chassis or would you do as we did? Yes, we certainly did tip that car over three times in order that we could make the weld each time in a horizontal position. Imagine making a weld on a modern car in that way. But that was the one and only time. We got busy practicing on channel iron in the shop and very soon could make the weld in any position.

The early days bring to mind the fact that I had frequent calls at one time from a very learned man, a professor in a school, who was much interested in welding and who in fact had specialized in the study of welding. This flame welding made no hit with him. It wasn't welding. Well,

what was it, then? Burning, just burning. A weld had to be pounded; there wasn't any such thing as melting a metal with a flame and making a weld. There couldn't be any strength to such a bond. Well, perhaps we might join cast iron in that manner but steel never. Continued visits made no impression upon him and it didn't take very long for talk of this kind to "get my goat." There was quite a lot of truth in some of his theories undoubtedly but I was pretty busy and almighty practical and I didn't see any sense in continuing the argument anyway. One day when he started the usual line of "you can't weld steel with a flame" I pointed to the yard where there were half a dozen automobiles with broken frames. I asked him if the frame of a car was steel and upon his answering yes, I told him that those frames were broken, that we were going to join the broken parts by melting them together and would add nothing except some more steel and would do no pounding. "When those cars leave this shop, those frames are guaranteed not to break. If they do, we give back the money we receive for the job. It doesn't make any difference whether its welding or burning to me—the frames are stronger when they leave here than they ever were and I don't want to discuss this subject with you again." That was his last visit.

You meet them every day though, don't you? They are the kind of men who believe that because a thing is beyond their comprehension, it isn't possible. They can't believe it even when they see it. Very much like the farmer on his first visit to the circus. Stood in front of the giraffe's cage for a long while gazing intently on the long neck and finally exclaimed, "Why, there ain't no sech animal."

These stories have always had morals attached but here it is rather difficult to think of one which meets the requirements of this particular instalment unless you agree with me that this one fits the case:

MORAL: The World is More the Gainer by a Good Welder Than by a Poor Story Teller.

WELDING STEEL MAINS.*

The growth of the use of the process of oxy-acetylene welding and cutting of steel has been phenomenal, as evidenced by statistics which show that the sale of welding apparatus in 1916 was practically double that of 1915. This growth is largely due to the extensive application of the process to the construction of gas mains and pipe line, inasmuch as the use of the process in the arts has been more or less firmly established for a number of years. A majority of the larger companies have experimented with the method and are now using it wherever possible. In natural gas and oil fields, especially in Oklahoma and Kansas, an enormous amount of pipe is being welded. The method has been used under all conditions, from congested city districts to country pipe lines, and in each, varied advantages are offered over previous methods.

Greater ease in manipulation, smoother progress, and lower costs obtained by welding in pipe-line work are advantages not to be overlooked, but in reality they must stand secondary to the value of the line after it is completed, as will be shown later.

Although the process of welding gas mains is in its infancy, it has sprung into rapid popularity and there is a wealth of information at hand, which makes it possible for those contemplating its use to be successful at the start. The general methods of procedure as laid down by the pioneers are commonly followed, but the details of better practice which are the result of a rather slow growth must come through the contributions of the experiences of the various companies. Hence, it is the object of the writer to correlate to a degree the results of former practice with those of the Western United Gas and Electric Company, and to make recommendations based on our experience in laying over fifty miles of welded main during the past season.

*E. E. Lungren, *before Illinois Gas Association*, 1917.

ADVANTAGES OF WELDING.

Leakage.

There are still a large number of distribution engineers who doubt the advisability of instituting welding because they feel that previous methods of laying mains have proved satisfactory, and that the special attention required in changing systems would be unwarranted. It is a fact that some gas men have become sluggish on the question of leakage, and have come to accept "unaccounted for" as a matter of course and an unavoidable evil. They are not excited over leakage figures unless they show a sudden increase, whereas in other lines of business an actual waste of 10—15 per cent. would demand investigation.

Every summer it is necessary for us to have at least one or two gangs of four men spend their entire time on maintenance of trunk pipe lines of screw pipe. These gangs renew sleeve and clamp rubbers, install new clamps, re-pack valves, etc., and all this aside from emergency cases which are handled by the different districts. On two of our lines, consisting of 40 miles of 8-inch pipe carrying gas at 50 pounds pressure, there are sections where nearly every coupling is covered by a leak clamp, in which some of the rubbers must be renewed every few years. During the past five years we have installed 1,064 rubber leak clamps on 156 miles of 4-inch high pressure pipe line and 1,318 clamps on 62 miles of 8-inch line. This is perhaps not unlike the experience of other companies, but it serves to show one item in the cost of maintaining screwed lines against coupling leakage.

If, then, we could joint mains by a method which would materially cut down this waste without sacrificing strength or convenience in construction, we would be justified in using this method even at an increased cost; but if we found by using this method that we actually added strength to the line at a lower cost, we would not be justified in adhering to screw-pipe.

In welding, these conditions can be obtained with the use of extra-heavy flanged steel valves and the elimination of rubber expansion joints, and we thus approach the ideal in leak-proof main construction. The properly welded joint is not only leak-proof during the construction period, but it is a positive assurance against the development of an incipient leak. Sometimes we find a sandhole in a weld, but it is always detected when testing, and is readily repaired by fusing the iron and building up around the hole. If a break should occur in a welding line, due to contraction stress on a poor weld, it must of necessity be of such size that it is quickly found and repaired; whereas, in a screw line a large number of small coupling leaks will develop which may never be detected except by barring.

Following we show the results of leakage tests on a new welded line and on a system of screwed pipe which has been in use for some years. This does not form an absolutely fair comparison inasmuch as the test on the welded line was made immediately after completing the line, whereas the test on the system of screwed pipe included the street mains of ten small towns which are connected with consumers. The test in the latter case was made during the period of minimum consumption, between the hours of 1 and 3 a. m., and the leakage indicated by the drop in pressure agreed within 2 per cent. of the actual figures of "unaccounted for." All of the towns were operating under governors and hence the leakage was based on the drop in pressure in the trunk lines. The welded line, being one of our first, was installed with cast iron screw valves and expansion joints, which accounts for the fact that there was an appreciable loss.

LEAKAGE ON WELDED AND SCREWED LINES.

Description	Gauge Pressure Lbs.	Pressure Drop per Hr. Lbs.	Leakage per Hr. Cu. Ft.	Leakage per Mile of Main per Hr. Cu. Ft.	Leakage per Mile Equivalent 3" per year Cu. Ft.
1. Welded Line.					
8 miles of 6"	30	¼	92.	3.5	20,075
18 " " 4"					
2. Screwed Lines.					
Trunk Lines.					
3.1 miles of 8"	15	1	3700.	19.9	182.500
3.7 " " 6"					
77. " " 4"					
11.4 " " 3"					
1.6 " " 2"					
Town Mains.					
10.4 miles of 2"					
66.6 " " 1½"					
12.5 " " 1"					
4 Compression tanks					
Vol. 6,740 cu. ft.					

Strength.

The weak point in a screwed line is either in a joint or in a cast-iron fitting. A welded joint, hqwever, when properly made is as strong as the pipe itself or it may even be stronger, depending on the amount of filling iron used. Cast iron specials, such as crosses, tees, drips, etc., which are always in danger of breaking, are eliminated and specials are welded up as needed from the pipe on the job. When a line is laid without strain the only strain it will encounter is that of contraction due to drop in temperature. A drop in temperature of 100° Fahrenheit will induce a stress of about 20,000 lbs. per square inch. Since the ultimate strength of steel is about 55,000 lbs. per square inch, contraction strains could not cause rupture unless there was a flaw in the pipe.

We would not say that a welded line is absolutely free from danger of breaking, because our experience has proved otherwise. During the past winter we have had two clean weld breaks, one on 6-inch and one on 8-inch. Neither of these welds had been made by first class welders, and the breaks clearly indicated that the welds had been made with the pipes butted together and the irop had not been fused to the bottom. The moral deducted from this experience is that men should not weld on line work until they have had plenty of practice under competent supervision in the pipe yard.

Here we show the results of tension tests on 1½" welded pipe, made by A. F. Blessing, of Swarthmore College, as shown in the Proceedings of the American Gas Institute for 1914.

TENSILE STRENGTH OF WELDED JOINTS.

Specimens	Kind of Pipe	Kind of Weld	Yielding Strength Lbs. per Sq. Inch	Maximum Strength Lbs. per Sq. Inch	Position of Failure
No. 1	Wrought iron	Plain	.....	49,500	Not in weld
No. 2	" "	"V"	30,000	48,650	" " "
No. 3	Steel	Plain	27,000	55,000	" " "
No. 4	"	"V"	27,000	54,900	In weld
No. 5	"	Sleeve	27,000	52,500	Not in sleeve joint

Operators.

In developing a corps of operators, the first step should be the employment of an experienced welder who can take charge of the instruction. Care should be taken in selecting the men who are to be taught to weld as it requires mechanical ability and the ability to appreciate the value of proper heats. It has been our experience that young men acquire the knack very readily. Welding is an excellent trade and the men should be brought to realize that it is a good opportunity for them.

The men are taught the general principles of welding and are shown how to regulate the flame for different pressures on various heads. It is important that they are shown how an excess of acetylene will cause carbonization, and an excess of oxygen will produce a "burned" weld. They are then allowed to weld pipe of small sizes and the joints made are tested with high pressure gas, and then are broken with a sledge in order that they may watch the progress of their work. After two weeks of this kind of work the men become quite proficient. Companies which would not require a number of operators, and which would not find it profitable to hire a man to do welding only, can send one of their men to work in the shop of apparatus manufacturers where they are willingly taught the fine points.

Welding Apparatus.

There are a number of welding torches on the market which differ mainly in the method of mixing the oxygen and acetylene. We have used to good success the torch in which the gases are mixed in the head very close to the tip. We have found that welders favor the torches which they used in learning to weld and do not adapt themselves readily to other makes though they be just as good.

Goggles.

The matter of goggles is not a small item inasmuch as the eyesight of the operator may be seriously impaired if the intense heat and light are not deflected. We have used a number of different makes and recommend the style that consists of a hard rubber frame with removable lenses of a dark amber shade which are covered by lenses of plain white glass. The welder should use the darkest shade practicable.

Outfit Carts.

A hand cart is very serviceable, giving plenty of room for all welders' tools, and is easily transported over rough roads as a trailer.

Welding Material.

Oxygen and acetylene are obtainable in cylinders containing 100 and 200 cubic feet under high pressure, and as service stations are located in all parts of the country it is possible to obtain prompt shipments any place. The acetylene should not be discharged at a greater rate per hour than one-seventh of the capacity of the containers as the acetone has a tendency to come over with the gas and cause carbonization of the iron. The use of acetylene generators on line work is not practicable because of the inconvenience in piping the gas to the welders who may be widely separated at times.

The filling iron used should be the best grade of Norway iron and for most work the use of wire 5/32" diameter is common practice. In welding pipe 8", and larger, ¼" rods may be used to advantage in that the iron does not tend to run so rapidly in the very hot flame necessary for these sizes. Bessemer iron rods are on the market at a somewhat lower price than Norway iron, but we have found that the difference in cost in relation to the cost of the weld was so small that it did not warrant the experiment.

Pipe Supports.

A pipe support which we have used to great advantage in lining up pipe, 4" and smaller, preparatory to welding, consists of a piece of 2½" angle iron, 2 feet long, welded to two pieces of 1½" pipe, 30 inches long. The pipe is lined up by simply placing the lengths in several of these angle irons and it can be turned easily in them as the weld progresses. By using five or six of these supports the pipe may be lined up without delay to the welder. For sizes larger than 4" the pipe is lined up on 2" x 4's, or 4" x 4's, and rolled during welding.

Roller.

We use a very convenient form of roller for moving long sections of large pipe. In making up sections ahead of the ditching gang it often happens that these sections must be moved several feet in order to make the final tie-ins; by using a number of rollers of this type the work is greatly facilitated. When an obstruction, such as a roadway crossover, occurs above the sub-grade of the trench a section may be moved along the bottom of the trench on these rollers.

Valves.

In the construction of welded lines without expansion joints, it is important that valves shall be of a type that will withstand contraction strains. The valve chosen should be one whose smallest cross-sectional area will show a strength at least as great as the strength of the pipe. In order to eliminate all threaded joints, flanged valves should be used with the pipe welded into the companion flanges. The total cross-sectional area of the bolts should be at least one-fourth greater than the area of the pipe, inasmuch as the bolts must withstand not only contraction strains but also the stress induced in making up the joint.

We have used extra heavy cast steel special gas flange valves and we obtained companion flanges with one-foot nipples welded in, from the manufacturer. Lead gaskets are used in making up the flange connections.

A valve recently designed by Mr. Keppelman, of San Francisco, is attracting some attention. It is a heavily constructed gate valve, operating somewhat on the principle of a stop-cock and is so designed that the dirt which is found in high pressure lines will not affect proper seating.

Main Extensions.

When the old main ends with a valve or cock a welded section of three or four lengths, threaded on one end, is screwed in; the opposite end extends above the ditch where the welding may be continued, thus eliminating a ditch weld. In making main extensions future laterals should be provided for by welding a nipple with a valve into the side of the main. For low pressure the nipple may be welded shut on the end and when later extended the nipple may be bagged off and the welded plug cut off. A bag-hole may be welded shut when there is low pressure in the main by supporting a four-foot piece of 6″ or 8″ pipe a few inches over the hole so that the flame is carried away from the operator.

A lateral may be cut in on an existing high-pressure main by carefully welding a short nipple to the main, building up the weld to give the necessary strength. The main may then be tapped through the valve installed on the end of the nipple. Mr. Wilde, in his recent paper before the American Gas Institute, has described a method in detail for tapping through a valve.

Service Connections.

As a substitute for saddles, line couplings may be welded on the main with the pressure on and the service connection made up with a street tee and street ell as usual, provided screw-pipe is to be used on the service. If services are to be all welded it is better practice to weld a welded tee to the main. The upright arm of the tee is threaded and after tapping is closed with a cap. The service may be tested before tapping by admitting pressure from the oxygen cylinder.

Exposed Pipe.

If a line is exposed, as for instance, one hung to the side of and run across a bridge, we have found it unnecessary to use expansion joints even though the pipe is subject to a wide range of temperature. We have a 3-inch line on a bridge which has been in use two years; the offsets at the points where the pipe enters the ground take up any induced strains. We are removing a large number of expansion joints from screwed lines on bridges, because of excessive leakage, and replacing them by welding in nipples. Mr. Wilde has shown a method of welding a cover over a leaking expansion joint which is advantageous where a line cannot be shut down.

Typical Methods of Welding.

There are two distinct methods of making pipe welds, (1) the forward weld in which the pipe is turned toward the torch and (2) backward weld in which the pipe is turned away from the torch. There seems to be some difference of opinion as to which method is most advisable to use. In the backward weld the flame is directed at right angles to the place of the filled-in iron and advocates of this method claim that the force of the flame tends to pile up the iron and blow out any slag which may be present. We have used the forward weld, in which the flame is directed in a semi-circular motion along the plane of the filled-in iron, and we believe that its advantage lies in the fact that the iron is subject to preheating in the reducing end of the flame which benefit is practically lost in the backward weld. With this method the fused iron is more easily controlled and there is less danger of the fused iron running to a cool spot in the pipe.

The welder should try to acquire different positions in making welds as it is indeed tiresome to sit in one position throughout the day. * * * * In line with comfort for welders each outfit should include a wagon-umbrella for use when working in the hot sun.

Degree of Chamfer on Pipe.

Practically all of the pipe we used during the past season was chamfered to an angle of 67° with the axis of the pipe, or a bevel of 23°. In lining up the pipe for welding it was necessary to leave a space one-eighth of an inch between lengths in order to fuse the iron at the inner circumference of the pipe. After having several breaks which were due to the fact that the iron was not completely fused through the thickness of the pipe, we rcecommend that the pipe be chamfered to an angle not greater than 60° with the axis, and it would be of still further advantage to have the bevel at 45°.

Laying Five Miles of 8-Inch Pipe.

During the past summer we laid a cross country trunk line of five miles of 8-inch pipe without installing a valve or fitting except at the ends. The methods used in the construction are typical for the nature of the work we encounter.

We had planned on using forty-foot lengths for this line, as it had been shown that this effects quite a saving, but as it was impossible to get prompt shipment at the time, it was necessary to use the random twenties. As soon as the pipe was distributed three welders with five helpers proceeded to weld the twenties into forty-foot lengths. The pipes were lined up on 4″ x 4″'s, and always sufficiently ahead of the welders so that they were not delayed. This method affords ideal conditions for lowering welding costs on a line and also makes it possible to proceed with less delay after trenching is started. The total average for the three operators was fifty welds per day and this preliminary work was completed in two weeks.

A machine was used for trenching which made a ditch 18″ wide to a depth of four feet. The trencher set the pace for the pipe-gang and enough welders were hired to keep up. The ditch was opened at the rate of 1,400 to 1,600 feet a day and three welders could easily handle the forty-foot lengths at that rate when no obstructions occurred.

After the trench was opened a section of pipe 100 feet long was welded on 4″ x 4″'s directly above the trench, one end of which was lowered into the ditch and welded into the existing main. The opposite end was supported above the trench and welded to another section. The work from there on consisted of making up sections as long as possible by making turning welds and then tieing in to the stub end of the line by a stationary weld above the ditch. In the early work on the line stationary welds were made when a section of six pipe lengths had been made up, but as the men became more experienced in handling the pipe, sections of 18 and 20 lengths were made up before tieing-in.

Each welder was furnished with a helper who turned the pipe and kept him supplied with materials. In addition to

this, five helpers were kept busy lining up the pipe and shifting the long sections into place so that there was no delay to the operator before starting a new weld. Two welders made up 80-foot and 160-foot sections, while the third made the 320-foot sections and then tied-in with the stationary weld. Two welders working on a 160-foot section, being turned by one helper over the ditch, works well. Out of 1,320 welds on this line, about 200 were stationary above the ditch and only three were made in the ditch.

The welders began the work using No. 8 heads, but with more experience we found that the work could be done much more rapidly with the No. 10. The welder should not be induced to use the larger head until he is absolutely capable of controlling the iron, inasmuch as the size of head sets the pace and the welder must keep up. On this line two welders averaged about 16 turning welds a day each, while the other welder made seven stationary and five turning welds. At a cross-road, where we were holding up traffic, a weld was made in 13 minutes; this is a rate, however, which could not be maintained all day.

Testing.

On this line we were particularly fortunate in being able to make up long sections above the ditch before testing. We supported a section of 4,000 feet long on 4″ x 4″'s above the ditch ready for testing; in no case did we test until one-half mile of pipe was welded. Driveway cross-overs for the farms along the line were made by lowering the pipe partway into the ditch on 4″ x 4″'s set crossways, then laying planks across the ditch. By testing only in long sections we economized on the gas used, as no valves were installed.

When the main was ready for testing it was capped with a rubber-gasketed cap which had been tapped for set screws, and the gas turned in at 30 pounds pressure. Each joint was tested with soap-suds, and the smallest leaks were easily found. In the first 190 joints tested 32 small sand-hole leaks were found, but as the work progressed and the welders became more experienced, the number of leaks was cut to a minimum. In the last mile not a single leak was found. The welder who made all the stationary welds did not have a leaky joint on the whole job.

Small leaks may be welded up with pressure on the main if the operator is careful not to fuse through the pipe. Sufficient strength is given by building up the iron considerably at the patch. If there is any possibility of an explosive mixture being present in the main, the patch should not be attempted until the main has been purged.

Lowering the Main.

After testing and repairing leaks the main was lowered into the trench by the use of two chain blocks supported on wooden horses. The main was lowered with the gas pressure on so that if a break should occur, it would be readily noticed. The first part of the line was re-tested after lowering into the ditch, but as no additional leaks were found the practice was discontinued.

We believe that mains, 8″ and larger, should be lowered into the trench with chain blocks or ropes as there is less danger of the pipe being laid under strain. With the smaller sizes, however, it is good practice to throw the main into the ditch; this serves as a good test for the strength of the joint.

A River Crossing.

One of our mains was laid under a river which is seventy feet wide and two to three feet deep. Owing to the fact that the river was to be dredged subsequently, it was necessary to lay the main four feet below the river bed.

A coffer dam was built half-way into the stream, and the five-foot offset shown was cut and welded on the road, using four pipe lengths. The offset was slid into position on skids and held with chain blocks while the tie-in was made. The main was then capped, tested and lowered into the ditch. The coffer-dam was opened and another one built on the opposite side of the stream to include the stub end of the pipe. An offset similar to the one mentioned above was made above the ditch, lowered into position and welded into the stub-end below the bed of the river. The ease with which such bends are made by gusseting the ends of the pipe, with the elimination of special fittings or fire-bends, stands out as one of the big advantages of welding.

The 8″ line ended by connecting in on a 4″ line at right angles. An 8″ x 4″ welded cross was welded in solid in the three lines, and an 8″ valve was installed on the open side of the cross for use on a proposed extension.

Cost Data.

We do not believe that the slightly lower costs obtained by welding mains should be considered as a leading advantage of the process because the cost of jointing mains is really small compared to the total cost of the line in any case, and hence have not taken the subject up under that head. The determining arguments in favor of welding are strength and minimum leakage, but companies contemplating the use of the process should not be deterred therefrom by fear of excessive cost. This company, starting with no previous experience, has laid its welded lines at a somewhat lower cost than previously laid screwed pipe.

Table I. shows the cost of laying several 4″ and 8″ screwed lines as compared with 4″ and 8″ welded lines laid under practically similar conditions. The costs as shown on the screwed lines include only the labor connected with jointing pipes, testing and lowering into the ditch. The costs of welded pipe include the time of welders and all welders' helpers in jointing, testing and lowering the main, and also the cost of all welding material. On the face of the figures it appears that the screwed lines were laid at a lower cost, but a further analysis prove the contrary.

TABLE I. COMPARATIVE COSTS OF SCREWED AND WELDED LINES.

	Screwed Lines.		Added Cost of Pipe Threaded	Welded Lines.	
Size	No. Feet	Cost per Foot	per Foot	No. Feet	Cost per Foot
4″	327,572	3.12 cts.	1.6 cts.	24,424	4.67 cts.
8″	166,533	5.95 cts.	3.5 cts.	27,230	6.88 cts.

In ordinary times, pipe companies give an added discount on bevel-end over threaded pipe, which amounts to about $2.00 per ton. With 4″ pipe this makes a difference in cost of 1.1 cents per foot; and with 8″, 2.5 cents per foot.

Further, we may consider the shrinkage in laying screwed lines, caused by the loss of about four inches of coupling at each joint, which is paid for as pipe. This amounts to 0.5 cent for 4″ and 1.0 cent for 8″. This may seem to be drawing a fine distinction, but it serves to prove the point.

TABLE II. COST OF WELDED JOINT.

Size	No. Welds	Filling per joint Pounds	Oxygen per joint Cu. Ft.	Acetylene per joint Cu. Ft.	Ratio Oxygen to Acetylene	Cost per joint, Welder, Helpers, Material
1½″	564	.076	1.5	1.37	1.1	$ .1815
2 ″	582	.111	2.15	1.93	1.11	.2378
4 ″	1230	.375	5.34	4.65	1.15	.927
8 ″	1320	.575	12.87	11.75	1.1	1.42

Table II. shows the material required in making rolls for each job. In planning future work these from total amount of material used and from the pay joints of several sizes, with costs per joint computed figures serve as a better guide than costs which are computed by taking gauge readings on oxygen and acetylene containers and by noting the time required by the welder on one joint. These costs are not offered as anything phenomenal, but they show what might be expected when a company is developing a corps of operators in its first year's work.

Table III. shows cost data compiled by Mr. Hirst, of the Peoples Gas Light and Coke Company, which is taken from

a general average of ditch and turning welds as encountered in their work. This table shows the economy of welding mains even in the congested districts of a large city, where underground obstructions are numerous.

TABLE III. AVERAGE WELDING COSTS.

Size	No. Joints	Cost Labor	Cost Acetylene	Cost Oxygen	Cost Filling Iron	Total Cost
4"	571	$ .17	$ .23	$ .18	$ .03	$ .61
6"	271	.27	.36	.29	.07	.99
8"	110	.41	.52	.44	.14	1.51
12"	948	.75	1.09	.77	.17	2.78
16"	57	1.02	1.38	.88	.22	3.50

NEW CHICAGO MANUFACTURER.

Chicago has long been noted as a center for manufacturers of welding equipment and apparatus, and the local trade has recently been strengthened by the addition of a new company. The Torchweld Equipment Company is the name of the new company, the factory and general offices being located at Fulton and Carpenter streets, Chicago. The company is headed by Mr. Carl J. Nyquist, president and manager, the secretary and treasurer being Mr. W. A. Slack, who will also act as sales manager. Both of these gentlemen will be remembered as being connected with the Western Oxygen and Gas Products Co., Los Angeles, Cal., Mr. Nyquist being manager and Mr. Slack sales manager. Recently these gentlemen disposed of their interests in the Western company and organized the new company.

The large factory building at Fulton and Carpenter streets is being remodeled and, when completed, will constitute one of the best equipped apparatus manufacturing plants in the West. In addition to the three floors which will constitute the apparatus manufacturing department of the new company, a large demonstrating department and commercial welding shop will be put in operation. This shop will be thoroughly equipped and in every respect prepared to handle the heaviest as well as the lightest welding work. The demonstrating and repair plant will be equipped with a 10-ton Whiting traveling crane, jib cranes, air compressor, automatic chipping hammers, portable power driven grinders, stationary grinders, drill presses, heat treating furnaces and, in fact, every labor saving and efficiency making machine known to the welding trade. The welding shop has been constructed and arranged with not only a view to the efficient handling of work, but also the comfort of welders as well. The ventilating system has received special consideration that the welders employed in the plant will find none of the discomforts sometimes found in welding shops. The shop as originally laid out is one of the largest in Chicago, but provision has been made for growth and expansion of the business. Automobile trucks will be operated to take care of the local deliveries.

Mr. Nyquist is one of the older members of the welding trade, in point of experience, being formerly superintendent of the Davis-Bournonville Shops at Jersey City. The company expects to market a line of high and medium priced torches and generators, parts, etc., all of Mr. Nyquist's design, and will also handle a full line of welding materials and supplies. Deliveries will begin in about six weeks.

OXY-ACETYLENE WELDING PRACTICE IN DES MOINES SHOP.

Different uses to which oxy-acetylene gas can be put in an electric railway shop are constantly being discovered by M. M. Lloyd, master mechanic Des Moines (Iowa) City Railway. On the new low-floor cars in Des Moines the gear cases have a clearance of only 2 11/16 in., and hence they often strike a stone or other obstruction on the roadway. This may make a dent in the case, and then the gear teeth cut a hole. We find a great many gear cases with such holes in them and they are quickly and easily repaired by welding a patch over the hole.

Worn center bearings on Westinghouse D2EG and D3EG air compressors are built up by the welding process. The babbitt is first taken out and the bearing filled in with metal to a depth of ½ in. or ⅝ in., after which the compressor case is placed in a drill press and the bearing housing bored out and fitted with a brass bearing. Worn journal side-plate bearings are also built up. The bearing way is filled and the journal is put on a planer and squared up, thus renewing the journal for a long period of service. The maintenance on the door-operating handles on a number of the cars was materially reduced by welding. These handles were previously riveted or held to the vertical rods with set screws and trouble was constantly experienced by their breaking off. To remedy this they were permanently welded in position.

The oxy-acetylene cutting frame was used to good advantage in a case in which it became necessary in the reconstruction of an electric locomotive to cut the door in the operating cab 5 in. wider. This meant the cutting of the ¼-in. steel side sheet through a vertical distance of 6 ft., and it was done readily with the acetylene flame, whereas it would have been a considerable problem to accomplish cutting by mechanical means.

Whenever a heavy casting or a particularly difficult piece of welding is to be done, it has been the practice to preheat the piece by the use of a home-made coal-tar burner connected with the shop air-pressure system.—*Electric Railway Journal.*

WELDING WIRE MARKET IN STRAITS.

A serious shortage of welding wire faces the users of such material. Prices in the last week have increased about 50 per cent. In 100-lb. lots ⅛-in. and larger sizes are now quoted at 28c per lb., 3/32 in. at 30c and 1/16 in. at 35c. Even these prices will not hold for long. The prices quoted are base prices to best customers only for delivery at best two or three months off. Dealers have practically no stocks and are not in a position to supply 25 per cent of their trade. The quantity of this material now available for wire-drawing will not last more than 30 days, and it will require three or four months to replace it. The wire-drawing capacity of the country is choked up and even if material was to be had it could not be pushed through the mills fast. It is probable that the practice of using Swedish iron mixed with alloy according to each manufacturer's formula will have to be abandoned, and that soft steel material, which does not have such a good low melting point and high tensile strength will have to be substituted.—*Iron Age.*

MAKING VALVE PUSH RODS WITH THE ELECTRIC BUTT WELDER.

By A. Towler.

The Studebaker Corporation, Detroit, Mich., finds that the Toledo electric butt welder simplifies the machining operations required in manufacturing valve push rods. These pieces have two parts. The head is bored out from bar steel, and the body is drawn in a punch press to shape.

The two elements are then united with the butt welder to form push rod, the outside diameter being 1.155 in. The production for this operation is 200 per hour. The outside is then finish-ground to 1.124 in. in diameter. By this method of making the push rod, a light-weight and yet a strong part is obtained. If it were to be made from a solid bar, it is easy to see that a somewhat difficult machining operation would be necessary.—*American Machinist.*

RADIOGRAPH *of* METALS

By Dr. Wheeler P. Davey

Research Laboratory, General Electric Company

Previous investigations by the author (insofar as these had been made) demonstrated the practicability of employing X-rays to detect flaws in the interior of metal castings, etc. Naturally, the next steps undertaken were the ascertaining of the limits of this new method of detection, the determination of the direction in which to expect a possible extension of the limits, the derivation of the working formulae for the work, and the acquisition of the necessary technique for its successful prosecution. In the following article the author describes these latter investigations and records their results.—Editor.

In an article in the *General Electric Review*, January, 1915, reference was made to the X-ray examination of a steel casting $\frac{5}{16}$ of an inch thick. Fig. 1 shows one of the radiographs thus obtained. All these radiographs showed plainly the tool marks on the surface of the casting. *All but one* showed peculiar markings which were of such shape as to strongly suggest that they were indeed the pictures of holes in the interior. A cylindrical piece, one inch in diameter, was punched from the casting at a point where the radiograph, shown in Fig. 1, indicated that a blow-hole should be found. (The location of the sample punched out is indicated by a circle.) Fig. 2 is a photograph of the side of the punching and it shows the hole that was found.

Since that article was written it has seemed desirable (1) to obtain data from which the exposure necessary for any thickness of steel could be at once calculated, (2) to find the thickness of the smallest air inclusion which could be radiographed in a given thickness of steel, (3) to find the direction from which to hope for further progress, and (4) to find the technique of radiographing metals.

In order to gain some preliminary data, several pieces of ¼-in. boiler plate were obtained, five by seven inches in size. In one of these, holes were drilled in such a way that the axis of each hole was midway between the faces of the steel and parallel to those faces. The diameters of these holes are listed in Table I.

Table I.

Hole Number	Diameter
1	¼ inch
2	$\frac{1}{8}$ inch
3	$\frac{1}{16}$ inch
4	$\frac{1}{32}$ inch
5	$\frac{1}{64}$ inch

Exposures were made on Seed X-ray plates at a distance of 20 inches with Coolidge tube X-117 which was operated on a Scheidel-Western induction coil having a mercury turbine break.

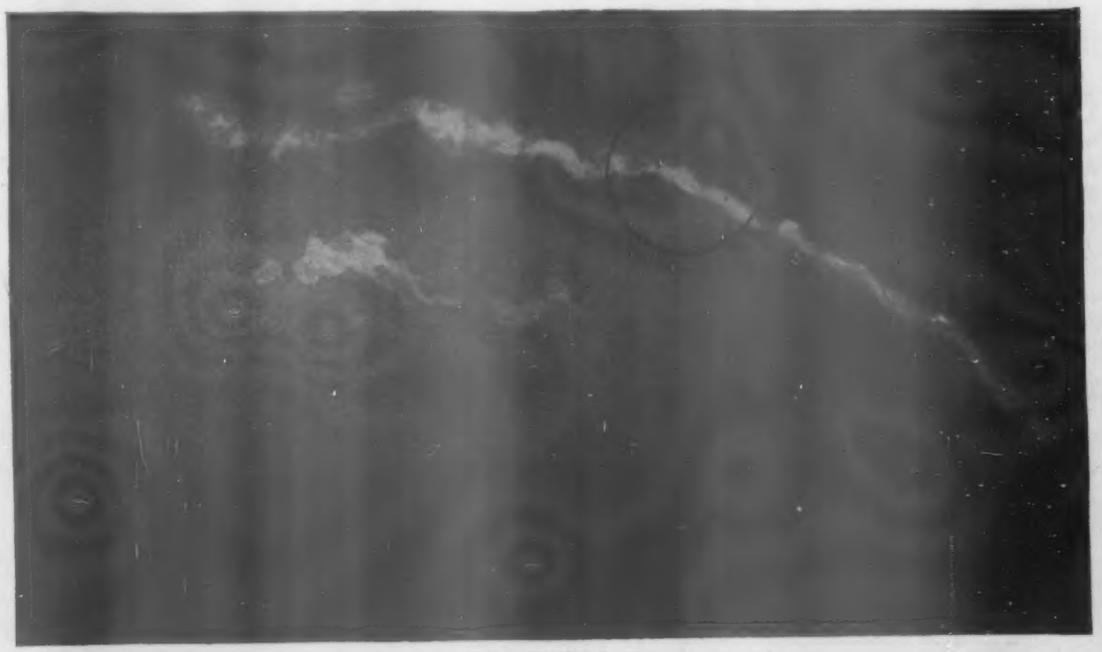


Fig. 1. Radiograph of a Steel Casting showing Flaw within Casting. The circle shows where a piece was later punched out

The X-ray plate was placed on a sheet of ⅛-in. lead. The steel plate was laid on this and a lead cover was placed over the whole in such a manner that the cover and backing made a complete lead-shield for the X-ray plate. (See Fig. 3.) A rectangular hole in the cover allowed such X-rays as were able to penetrate the steel to reach the X-ray plate. This afforded complete protection against secondary rays. Without such precautions, the effect of secondary rays on the X-ray plate would have been greater than that of the rays used to take the picture. If the steel had been two or three feet square, such precautions would have been unnecessary. By placing the pieces of boiler plate on top of each other any thickness of steel desired could be obtained. Exposures were made at 11-, 13- and 15-in. parallel spark-gap between points. An attempt was made to use a 17-in. spark gap, but was abandoned due to flashing in the tube. The results are tabulated in Table II.

Table II.

Thickness of Steel in In.	Plate	Spark Gap	Exposure in Milliampere-Minutes	Holes visible
½	D	11	7	1-2-3-4-5
	A	13	4	1-2-3-4-5
	B	15	2	1-2-3-4-5
1	E	11	45	1-2-3-4-5
	F	13	19	1-2-3-4-5
	G	15	10	1-2-3-4-5
1½	H	11	45	1-2-3 *very* faint
	I	13	30	1-2-3 very faint
	K	13	90	1-2-3 faint
	J	15	30	1-2-3-4-5 very faint
	L	15	60	1-2-3-4-5 faint

This really means, of course, that at 13-in. spark-gap 90 milliampere-minutes is sufficient to enable one to notice the difference in blackening between exposures through $1\frac{7}{16}$ in. and

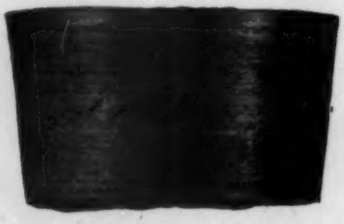


Fig. 2. Ordinary Photograph of one edge of the punching from the plate shown in Fig. 1. Note flaw

1½ in. of steel, but is not sufficient to enable one to detect the difference in blackening between exposures through $1\frac{15}{16}$ in. and 1½ in.

Thse results were necessarily incomplete, since the plates were by no means all of the same density. They served, however, to demonstrate two facts.

(1) With the voltages which can now be used, it is impracticable to radiograph through more than 1½ in. of steel with tungsten target tubes because of the time required.

(2) The use of high voltages does not seem to appreciably reduce the clearness of the picture obtained. (It was to have been expected from published data on scattering in aluminum that enough scattered radiation would have been produced to blur the pictures, but plate *B* apparently shows as good detail as does plate *D*.)

It remained to verify these conclusions by data of a quantitative nature. Seed X-ray plates were therefore exposed under the same conditions as before except that none of the slabs of steel used had been drilled. For each thickness of steel, all the exposures at a given spark-gap were made on the same plate. Each plate, then, showed a series of steps which increased in density from one end of the plate to the other. Thickness of steel, spark-gap, and milliampere-minutes were recorded on each plate by means of lead numbers. Data regarding these plates is listed in Table III.

Table III.

Plate No.	Thickness of Steel	Spark-gap
216	½	11 inches
217	½	13 inches
218	½	15 inches
221	1	11 inches
220	1	13 inches
219	1	15 inches
222	1½	15 inches

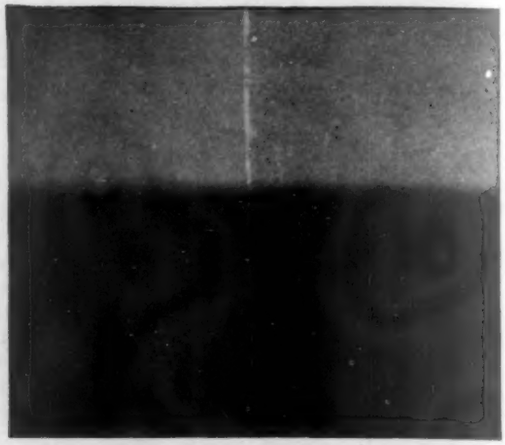


Fig. 4a. Radiograph of Autogenous Weld in Steel. Sample No. 1. Only the surfaces have been welded

Fig. 4b. Diagram of Section of Weld in Sample No. 1

A study of these plates showed the following facts. Let $E_{1/2}$ be the exposure in milliampere-minutes necessary to produce a given darkening of the plate through ½ inch of steel,

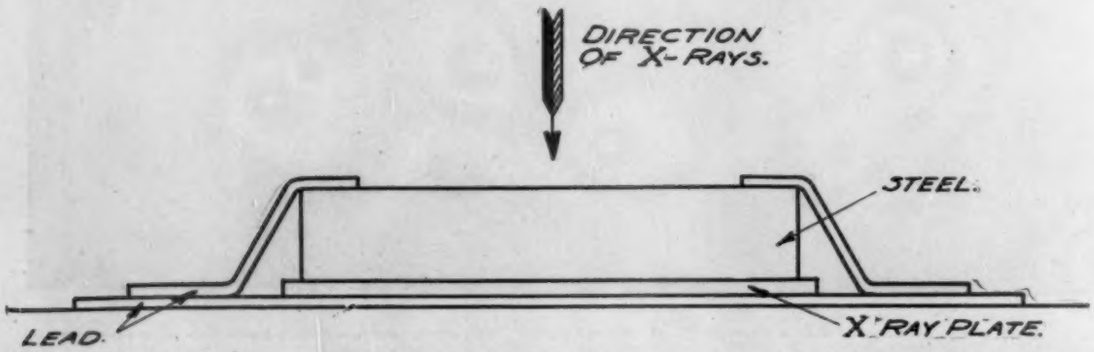


Fig. 3. Diagram of the Method of Preparing Steel Sample, X-ray Plate, Lead Mask and Lead Backing for taking Radiograph

and let E_1 and $E_{1\,1/2}$ be the exposures necessary to produce the same darkening through 1 inch and 1½ inch respectively. Then at 11-in. gap.

$E_{1/2}:E_1=1:11$

At 13-in. gap

$E_{1/2}:E_1=1:8$

At 15-in. gap

$E_{1/2}:E_1=E_1:E_{1\,1/2}=1:8$

Also, through both ½ inch and 1 inch of steel

E 13-in. gap : E 11-in. gap = 1 : 4

and E 15-in. gap : E 13-in. gap = 2 : 3

It is at once evident that *either* X-rays from a tungsten target at 13-in. gap are more penetrating than when produced at 11-inch gap, *or* the X-ray plates used are more sensitive to the rays produced at 13-in. gap. There is other evidence to show that the first of these conclusions is the more probable, but it is the

effect of the X-rays on the plate which is of prime importance in this work, so that from a radiographic standpoint we may say that in any case the *effective penetration* of the rays is a little greater at 13-in. gap than at 11-in. gap.

In the same way we may conclude that the effective penetration at 15-in. gap is the same as at 13-in. gap. There is, however, a marked decrease in the amount of exposure required as the voltage across the tube (as measured by the spark-gap) is increased. This may be due to one of two causes, *either* the

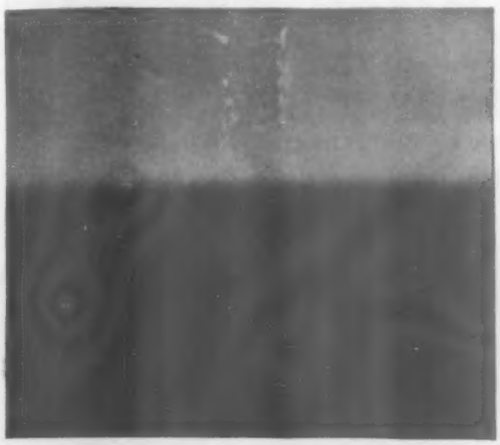


Fig. 5a. Radiograph of Autogenous Weld in Steel. Sample No. 2. Holes in center due to metal not being thoroughly fused

Fig. 5b. Diagram of Section of Weld of No. 2

efficiency of transformation from the kinetic energy of the cathode stream into the energy of the X-rays may be greater at high voltages, *or* there may be some peculiarity in the wave-form produced by the induction coil such that a great deal of energy is given off at a voltage corresponding to 13-in. gap when the coil is operated so as to give a maximum voltage corresponding to a 15-in. gap. Investigation work on crystal-reflection of X-rays will serve to decide between the two hypotheses.

From the data at hand, it is easily possible by well known

Fig. 7b. Diagram of Section of Weld in Sample No. 4

means to construct formulæ for computing the exposure necessary for radiographing steel at various spark gaps.

Let Q_0 be the quantity of X-rays impinging on the steel during the exposure.

Let Q be the quantity of the rays which pass through the steel.

Let χ be the thickness of the steel.

Let λ be the coefficient of absorption of the steel. Then, if the X-rays are homogeneous.

$$Q = Q_0 \epsilon^{-\lambda x}$$

Where ϵ is the base of natural logarithms.

Now at 15-in. gap we know that $\frac{E_{1/2}}{E_1} = \frac{E_1}{E_{1\,1/2}} = \frac{1}{8}$

The rays given off at 15-in. gap are therefore practically homogeneous. Since $\frac{E_{1/2}}{E_1} = \frac{1}{8}$ at 13-in. gap, we may assume that these rays are also practically homogeneous. Rays given off at 11-in. gap are still sufficiently homogeneous, after having passed through the first few hundredths of an inch of steel, to allow of being treated as though they were actually homogeneous. Calculations for exposures at 11-in. gap are to be considered as being only good approximations.

For 15-in. gap we have

$$Q/Q_0 = \tfrac{1}{8} = \epsilon^{-x}\lambda = \epsilon^{-1/2}\lambda$$

$$\log 8 = \tfrac{1}{2}\lambda = 2.079$$

$$\lambda = 4.16 \text{ inches}^{-1} = 1.64 \text{ centimeters}^{-1}$$

Likewise for 15-in. gap

$$\lambda = 4.16 \text{ inches}^{-1} = 1.64 \text{ centimeters}^{-1}$$

Applying the same method for 11-in. gap

$$\lambda = 4.80 \text{ inches}^{-1} = 1.89 \text{ centimeters}^{-1}$$

Now at 15-in. gap and 20-in. distance, 0.8 milliampere-minutes gives a good exposure through ½ inch of steel. A corresponding darkening would have been produced on a bare (unobstructed) plate by an exposure of 0.1 milliampere-minutes. This corresponds to Q in the formula. We may therefore write, since $Q_0 = E$,

$$0.1 = E\epsilon^{-61.6\,x}$$

$$10\ E = \epsilon^{4.16\,\chi}$$

$$\log_\epsilon 10\ E = 4.16\ \chi$$

$$\log_{10} 10\ E = 1.80\ \chi$$

$$E = 1/10\ \log^{-1}_{10}\ 1.80\ \chi$$

where χ is the thickness of the steel in inches or

$$E = 1/10\ \log^{-1}_{10}\ 0.71\ \chi$$

where χ is the thickness of the steel in centimetres.

The corresponding formulæ for 13-in. gap are

$$E = 3/20\ \log^{-1}_{10}\ 1.80\ \chi \quad (\chi \text{ in inches})$$

$$E = 3/20\ \log^{-1}_{10}\ 0.71\ \chi \quad (\chi \text{ in centimeters})$$

The approximate formulæ for 11-in. gap are

$$E = 3/5\ \log^{-1}_{10}\ 2.09\ \chi \quad (\chi \text{ in inches})$$

$$E = 3/5\ \log^{-1}_{10}\ 0.82\ \chi \quad (\chi \text{ in centimeters})$$

It remained to find the thickness of the smallest air-inclusion which could be radiographed in steel at 15-in. gap. For this purpose two plates of steel were taken. The faces were machined flat and in one of them a slot was cut, thus giving a

Fig. 6a. Radiograph of Autogenous Weld in Steel. Sample No. 3. Weld is porous

Fig. 6b. Diagram of Section of Weld in Sample No. 3

wedge of air. The slot and the faces of the steel plates were then ground smooth. When completed, each plate was ⅝ in. thick. The air wedge was 10 inches long, 1 inch wide, and $\frac{1}{16}$ inch thick at its thick end. When the two plates were bolted together, the air wedge simulated a blow-hole in a casting.

The wedge was then radiographed at 15-in. gap. When the X-ray plates were dry the place was noted at which the outline of the wedge was barely visible. In order to avoid error, only a small portion of the wedge image was viewed at one time, the remainder being blocked off with cardboard. It was found that an air inclusion 0.021 inch thick could be detected in 1¼ inches of steel. In ⅝ inches, an air inclusion of 0.007 inch could be detected.

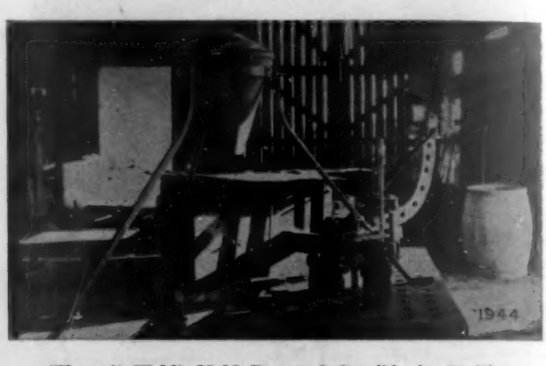
Besides the work that has been outlined herein much more has been done in the actual taking of pictures so that the technique of radiography through metals might be worked out.

A record of a single example will suffice. Four samples of autogenous welds in steel were obtained. The welding had been done with an oxy-acetylene flame. The samples were ½ inch thick and about 4 inches square, and their faces were fairly rough. Sample No. 1 had only been welded on the surfaces. (See Fig. 4b.) Sample No. 2 had been insufficiently heated so that there was incomplete fusion of the metal at the center. (See Fig. 5b.) In welding sample No. 3 an excess of oxygen had been used in the flame, which caused the presence of oxide on the surface. (See Fig. 6b.) Sample No. 4 was considered to be a good weld. (See Fig. 7b.) One-half of each face of the samples was machined off, so that half the length of the weld was between flat, parallel faces; the other half was left under the original rough surfaces. As a result, one-half of each sample was ½ inch thick and the other half was about ⅜ inch thick. Radiographs were taken at 15-in. gap under the conditions described above. Reference to the formula for exposure at 15-in. gap shows that the exposures through the ½ inch and ⅜ inch portions were in the ratio of 1 to 17. The resulting radiographs are shown in Fig. 4a, 5a, 6a, and 7a.

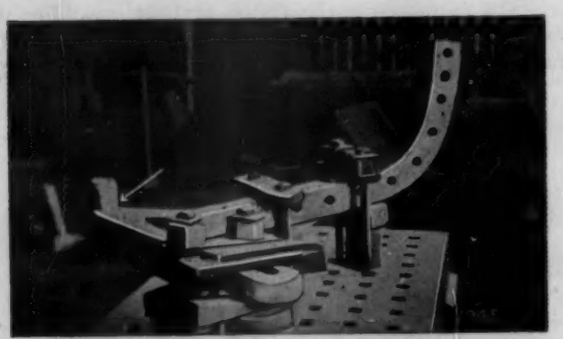
Fig. 4a shows clearly the unwelded center of sample No. 1 in both portions of the picture. Fig. 5a shows, in both portions of sample No. 2, the holes caused by the metal not having been thoroughly fused at the center. That portion of Fig. 6a which was taken through the machined end of the weld of sample No. 3 would seem to indicate a porous structure. Such a structure was evident during the machining. The portion of the picture taken through the unmachined end of the weld did not show such a structure with certainty. This was to have been expected, as the inequalities in thickness due to the uneven surface were at least as great as those due to porous or frothy structure. Fig. 7a shows that, as far as gross structure is concerned, sample No. 4 was a good weld.

It is of course self-evident that a radiograph gives only the gross structure of the metal, and gives no information as to the "grain," crystal interlocking at the edge of the weld, etc. A radiograph does, however, give valuable information as to the presence of blow-holes, slag inclusions, porous spots, and defects of like nature which could not be found otherwise except by cutting into the metal. Unfortunately, no fluoroscopic screen now known is sensitive enough for this work, therefore all work in metals must be done radiographically. An inspection of the formulæ that have just been derived demonstrates that, for the present at least, radiography of steel is a commercial possibility only up to thicknesses of ½ inch. For greater thicknesses, the time required is rather great. The big saving in time which is gained by the use of a 15-in. spark-gap instead of a 13-in. gap makes it seem probable that a further increase in the voltage across the tube would allow one to radiograph still greater thicknesses of steel.

Thermit Weld in Large Dredge Dipper. Lined Up for Welding



(Thermit Weld) Mold Box and Crucible in Position



Thermit Weld with Riser and Pouring Gate

(Thermit Weld) Finished Weld with Casting Ready for Service

NEW HAUCK CATALOG.

The Hauck Manufacturing Co., 140 Livingston St., Brooklyn, have recently published booklet No. 82-W, which tells of preheating methods and apparatus. Copies will be sent to welders upon request.

FORGE WELDING.

Editor: I do not think it economy to supplant forge welding with oxy-acetylene welding unless there is a decided gain. Referring to M. Wiese's article (March, 1917) in Ford parts, admitting that the ring weld is somewhat difficult without dies, there would be a considerable saving to swage the bolt end from the original stock, as an ordinary smith with trip hammer dies could swage four or five hundred per day, or an experienced carriage smith, with helpers, without power, could turn out 250 in the same time.

F. L. Snyder.

THE VALUE *of the* OXY-ACETYLENE APPARATUS *in the* RAILROAD SHOP

By B. Kopferschmidt

The modern railroad shop is about the greatest field where the oxy-acteylene welding and cutting apparatus is demonstrating its value. This field is not limited to rough or heavy work only, but it covers operations where neatness and accuracy is absolutely necessary. It covers not only repair work, but a great deal of production work, distributed in different stock rooms of the system.

The welding torch is applied to cast steel, hard steels, boiler steel, wrought iron, cast iron, malleable iron, copper, bronze, brass and aluminum. The cutting torch is also a familiar sight in a railroad shop, cutting of bolts, rivets, locomotive frames, fire-box sheets, scrap, etc.

It is the practice in some railroad shops to limit the use of the apparatus to a round house or an erecting shop. Others are using it only in the boiler shop. Such practices mean that some railroads do not get the full benefit of the gas welding device. The round-house, boiler, machine, tank and pipe-fitting shops are all like five fingers to a hand, and if all work on a uniform speed, then efficiency is greatly increased.

Fig. 1. Broken Locomotive Cylinder

Fig. 2. Furnace for Preheating Cylinder

In visiting a railroad shop on any working day one can always find some interesting welding jobs, and to illustrate this, the writer has taken a number of photographs of some of the work on hand at the different departments, before and after welding.

Fig. 1 represents a locomotive cylinder broken in two places. One break was about 20 inches deep and about 26 inches in circumference. The other break was about 5 inches deep and 12 inches in circumference. After the pieces were bevelled to a 45 degree angle they were tacked temporarily in the proper places, then the cylinder was set on a brick platform so it could be turned around to facilitate the welding of both pieces, while in the furnace, and after that a brick furnace was built around the cylinder, with a 6-inch fuel displacement. The bottom row of bricks were separated, about one inch apart, for draft purposes, and the front wall had a 24-inch square hole covered with sheet asbestos, as shown in Figure 2. This hole was left open so the operator could do the welding by removing the sheet asbestos.

Figure 2 shows the furnace while casting is being preheated. The furnace was filled up with charcoal and coke and kindled through the bottom row of holes with the welding blowpipe, and after four hours preheating the casting was cherry red and ready for welding. The operator commenced at the flange and with the aid of carbon blocks, both vertical welds were made; then the whole of the large patch was welded. With the aid of our chain block (Fig. 3) the cylinder was turned towards the left side, and as the cylinder was still red hot, the smaller patch was welded by the same method. After the welding operation was finished all the holes were covered with fire clay and left to cool for 24 hours.

Figure 3 shows the cylinder welded and ready for machining. The cost to weld this cylinder was $9.80 and a new one

Fig. 3. Cylinder Welded and Ready for Machining. Welding Cost $9.80. New Cylinder Would Cost $210.00

Fig. 4. Locomotive Cylinder Cracked Through Whole Length of Cylinder

Fig. 5. Welded Locomotive Frame. A New Six-inch Piece Was Welded In This Frame at a Cost of $5.75, Welding Time Being One Hour

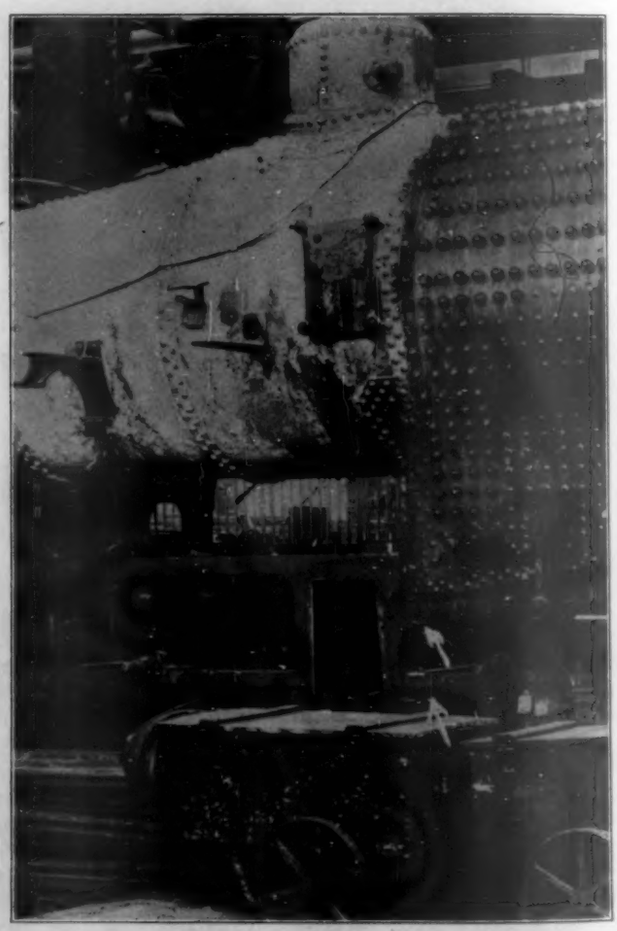


Fig. 6. Upper and Lower Rails of a Locomotive Frame Welded. Cost of Two Welds $15.70, Welding Time Being 5½ Hours

Fig. 7. Back Pedestal of a Locomotive Frame, Welded Close to Upper Rail Frame. Frame Was Six Inches Square and Was Beveled Both Sides

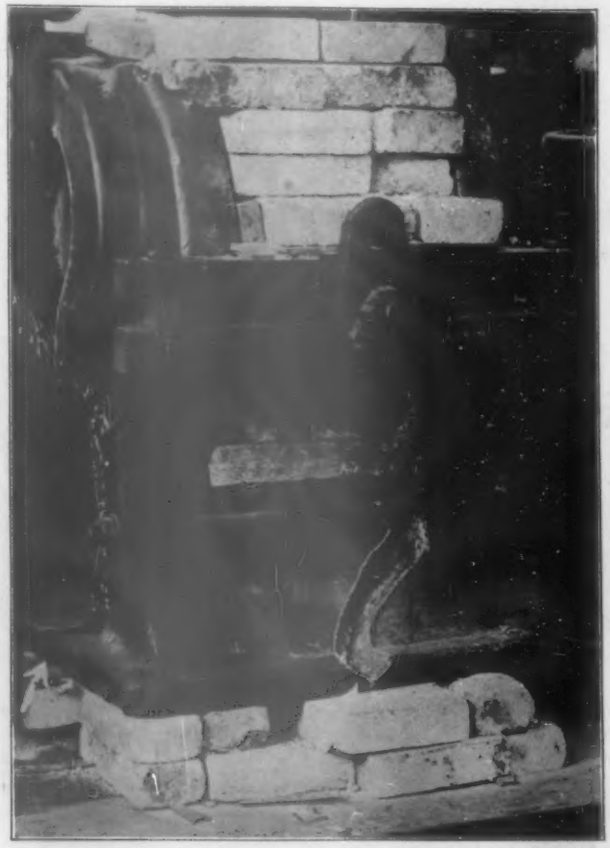


Fig. 9. Front View of Broken Buldozer, Showing Three-inch Metal Wall. In This Job Great Care Was Used to Keep Parts in Place.

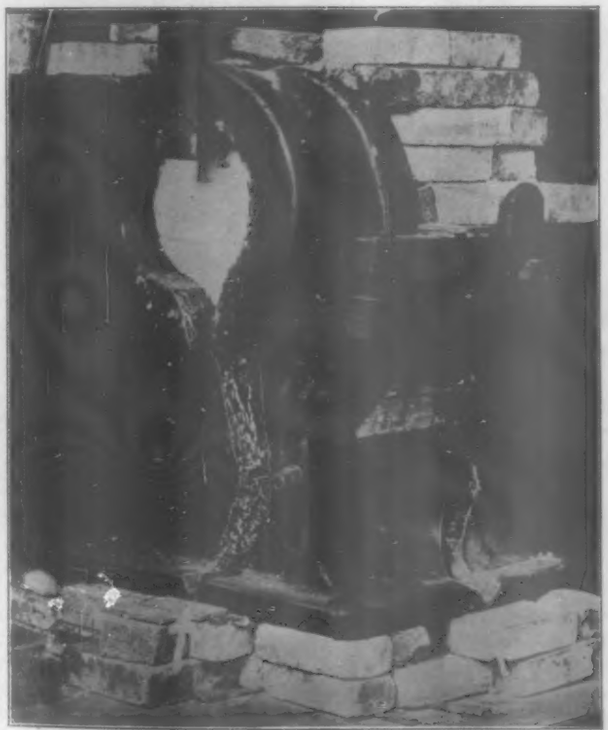


Fig. 8. One View of a Cast Iron Ajax Buldozing Machine, Before Welding

Fig. 10. One-eighth Out of Alignment Would Make This Machine Useless. Note Clamp for Broken Parts

would have cost the railroad $210.00. The time of actual welding was four hours.

Figure 4 represents another locomotive cylinder before welding, same being cracked through the whole length of the cylinder.

Figure 5 represents a locomotive frame welded. This frame is about 2 inches thick and about 8 inches wide, and

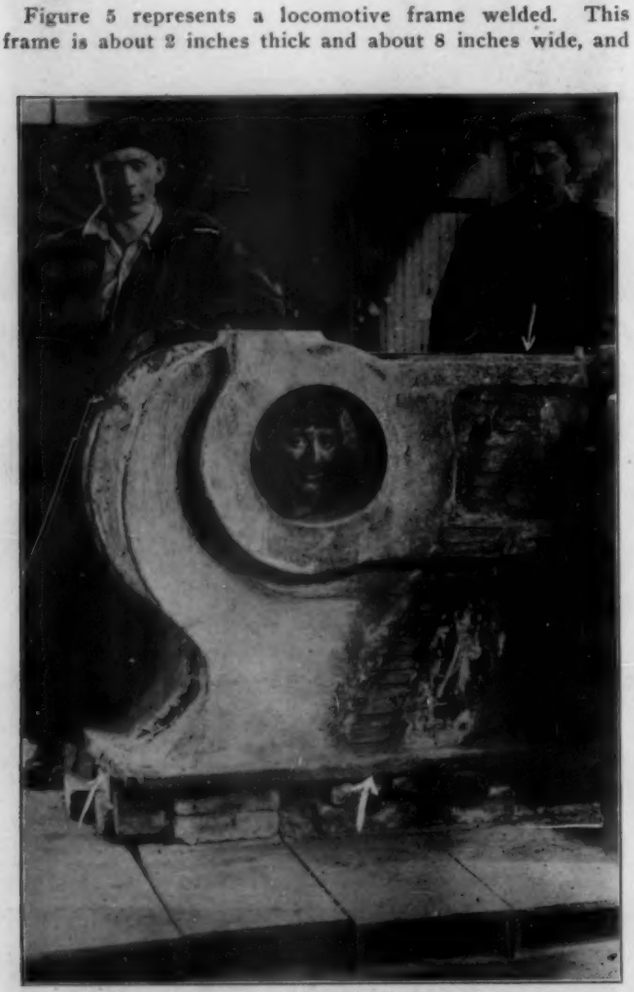


Fig. 11. The Finished Weld

had at that place an old oil weld. Therefore it was necessary to cut off 6 inches in length and a new piece bevelled on both sides was welded in by two operators, one on each side of the frame. The cost to weld this frame was $5.75 and the actual welding time was one hour.

Figure 6 shows the upper and lower rails of a locomotive frame welded. The upper rail is 4½ inches by 5 inches and the lower one 3 inches by 5 inches. A jack was placed across the fractured frame for the purpose of expanding or separating the fractured ends to about ⅛ inch. The frame was bevelled on both sides so two operators could weld at each side of the frame. The upper rail was preheated and welded During the second weld, the preheating burner was kept on the upper weld until the lower weld was completed. The cost of the two welds was $15.70, and the actual welding time was 5½ hours.

Figure 7 represents a No. 3 back pedestal of a locomotive frame, welded close to upper rail frame. This frame was six inches square and was bevelled at both sides of the frame. The binder was replaced between pedestals and with the aid of a screw jack and iron wedges the ends were separated ⅛ inch. After the frame was preheated to a bright red and the bevelled surfaces brushed off from the iron oxide with a steel brush, the frame was welded by two operators at the same time, and finished in about four hours. Then the welded portion was anealled and hammered and left to cool.

Figures 8, 9 and 10 represent one cast iron ajax bulldozing machine, broken in three parts.

Figure 8 shows the right side view with a six inch thick metal wall. Figure 9 shows the front view with a three-inch thick metal wall and Figure 10 shows the left side view with a four-inch thick metal wall. In welding this machine it was absolutely necessary to keep the broken parts in proper places. One-eighth-inch out of alignment would make this machine useless, therefore we clamped the broken parts back in place and while clamped, the necessary chipping was performed, so as to form the 45 degree bevel without moving it from its position. Then we found that our welding shop 5-ton crane could not handle this job, so we had to use the erecting shop crane, and perform the welding operation at the erecting shop. We also made for this purpose a special welding table. After one row of fire bricks was set on the table we set the machine level and then built a furnace on the inside of the machine, as per figure 9, both side wings of the machine being

Fig. 12. Another View of the Finished Weld

used as side walls. Then we filled this space with charcoal and coke and left it to heat the whole night. The next morning the preheated portion was cherry red and the job was ready for welding. We used two water cooled, long handled blowpipes, and figured on making all three vertical welds while in one position. For this purpose we had prepared carbonized blocks, one inch thick, six inches square, as per

figure 10. On one edge of these blocks we cut off a half round hole, about 1½ inch deep and about two inches wider than the bevel. This half round space was filled with cast iron and acted as a reinforcement to our welds. Two operators, one on each side, started to weld by placing one carbon at a time. After the bevel in the casting was welded the height of the carbon, the half round space was filled also with cast iron. Then another carbon block was placed on

Fig. 13. The Cost to Weld This Machine Was $82.00. A New Machine, If It Could Be Procured, Would Cost About $1,200.00

top and continued so until the top end was reached. During this operation more charcoal and coke was fed in the oven to keep the casting hot, and two other operators were standing by to relieve the other two when overheated. When the welding was finished on both sides, one operator welded by the same method the front break and at 6 p. m. the job was finished. We then covered the outside heated portion with sheet asbestos and left it to cool for 48 hours. After the asbestos bricks and carbons were removed, the welds, including the reinforcement, appeared similar to thermit welds, as shown in figures 11, 12, 13. The cost of welding this machine was $82.00 and a new one, if the railroad could obtain it at the present time, would have cost $1,200.00. Actual welding time was 11½ hours.

Fig. 14. Patch Welded on a Main Air Reservoir. Cost of Welding $1.58

Figure 14 represents a patch welded on a main air reservoir. This patch was tacked on one side, then iron wedges were driven about every 8 inches around the welding line. The weld was started on one side near the head and continued so by removing the wedges one at a time until the other end was reached. This patch was about 15 inches in diamter and it required 1½ hours to make the weld. The cost of welding was $1.58 and if same would have been applied with patch bolts by the boiler makers it would have cost $7.50. A new reservoir is worth $96.00.

Figures 15 and 16 show two large patches welded in a locomotive fire-box. The vertical welds running in a curve

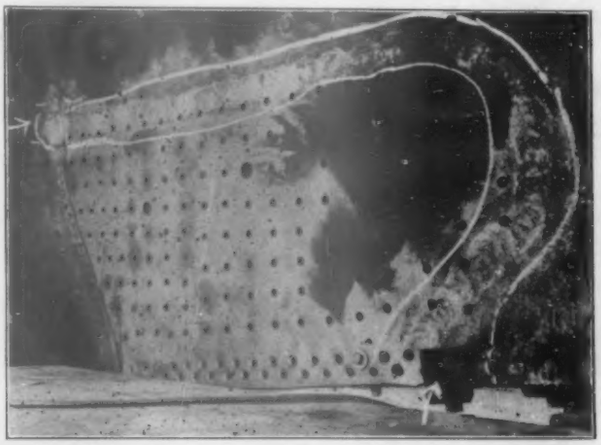


Fig. 15. Large Patch on Locomotive Fire Box

or open angle should be given the preference over the straight vertical welds. These patches, after they were properly beveled and clamped, were tacked at the horizontal line and iron wedges driven on the curved line about 6 inches apart. The horizontal welds were started from the flue sheet end. One operator on each side of the box continued the welding until the third row of staybolts below the horizontal welding line was reached. Actual time of welding was 5 hours and

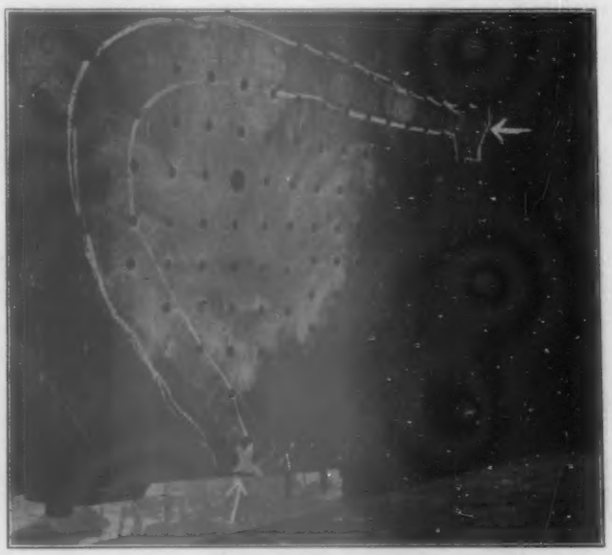


Fig. 16. The Saving on These Two Patches, Over the Boiler Maker's Method, Was $27.00

cost $10.00. The saving on these two patches over the boiler maker's method was $27.00.

Figure 17 represents a ¼ door sheet welded, the rest of the sheet being in good condition. This weld was performed by two operators. After iron wedges were driven about 6 inches apart, one man started to weld at the left side, and the other one at the center and thus finished welding about the same time. Actual welding hours were 1½ and cost $4.80. We saved on this job $5.50.

Figure 18 represents one of the two side sheets welded in a locomotive fire-box. After the sheets were clamped so the surfaces should be level, iron wedges were driven about every 6 inches, and then tacked about every 7 inches. Then one operator started to weld from one end, and another one from the center and thus finished the welding in 3 hours per sheet. The cost to weld both sheets was $9.30 and we saved on this job over the boiler makers' method $3.85. But the real saving counts on the future maintenance, there being no cost of upkeep if seams are properly welded.

Figure 19 represents an electric locomotive and the arrow

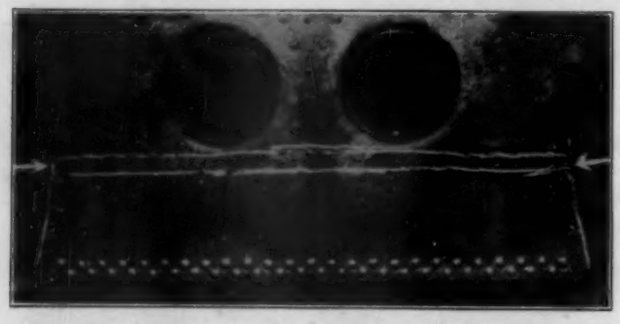


Fig. 17. Door Sheet Welded. Cost of Welding, $4.80. Saving, $5.50

shows a cast steel front beam that was broken in two halves at the center behind the coupler casting. This casting being very large and heavy and the acetylene operators too busy, we agreed to try other welding methods; but these methods failed to make a strong job and it was up to the oxy-acetylene blowpipe to do the welding. With our reinforcing method we welded this casting in 48 hours at a cost of $136.00 and put in operation the third day. After the locomotive was a few weeks in service, it hit another one that had a solid new beam and the welded beam not only broke the new beam, but also broke the heavy frame of the locomotive. This was certainly a good test to show what reinforcing will stand in a heavy casting in case of a wreck. A new front beam cost at the present time about $800.00 and until the present time we welded three such castings.

Without the oxy-acetylene welding device some of these

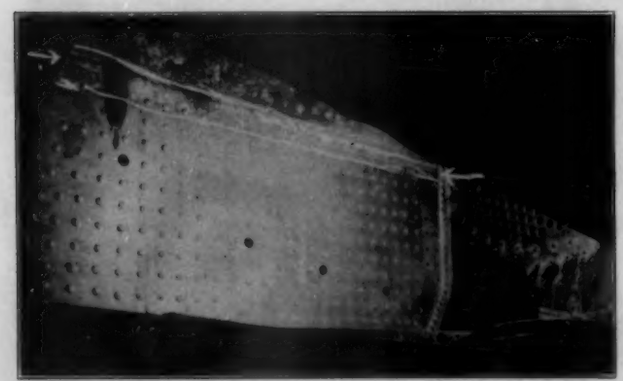


Fig. 18. Side Sheet Welded in Locomotive Fire Box

articles would be useless and fit for the scrap pile, and by reclaiming them at the present time, the oxy-acetylene blowpipe has won for itself a place of distinction and value beyond any other tool employed in the railroad shop.

The Davis-Bournonville Company, Ltd., has been granted permission to manufacture the following articles in Ontario with a capital stock of $40,000: Machinery, power apparatus, tools, to cut, melt and weld metals, etc. Thomas D. Sutherland, Niagara Falls, Ont., has been appointed attorney for the company.

DUFFY NEW COMMERCIAL MANAGER.

Mr. Thos. H. Duffy, on May 1st, succeeded Harry G. Doran as Western Manager of the Commercial Acetylene Welding Company, with offices at 3950 S. Wabash Ave., and in the Peoples Gas Building, Chicago.

Mr. Duffy has been connected with the Commercial Acetylene Companies in various capacities since 1906. The last seven years he has been Assistant Western Manager.

DORAN IN SUPPLY BUSINESS.

Harry G. Doran, after sixteen years' service with the Commercial Acetylene interests, has resigned and opened an office in the Peoples Gas Building, Chicago, to act as manufacturers representative specializing in railway supplies.

He is also being retained by the Commercial Acetylene Welding Co. for special work.

The General Welding & Equipment Co., 107 Massachusetts Ave., Boston, have published a pamphlet entitled "Cutting With Oxygen." A new bulletin has also been published describing welding and cutting equipment.

A bulletin (No. 101) has been issued by the Bradford-Ackermann Corporation, 42nd St. Building, New York, describing "Astra" Oxy-Illuminating low pressure gas apparatus, especially designed for lead burning purposes. This apparatus can be used to advantage and with economy by storage battery service stations, garages, etc., and other

Fig. 19. Arrow at Lower Right Indicates Weld in Cast Steel Front Beam

similar places where lead burning, hard tempering, etc., is done. The scope of the apparatus can be broadened by means of special apparatus to include cylinder decarbonizing and oxy-acetylene welding and cutting.

THE CUTTING TORCH ON DIE WORK.

An interesting example of cutting with the oxy-acetylene torch was recently performed with the Davis-Bournonville apparatus. This was on a steel die block 14x18x36 in., weighing 2,382 lbs. The block was cut to make two pieces 14x16x18 inches.

The torch was style 3000, with a No. 5-8 tip. The time required to make the cut was 9½ min., and the gases consumed were 325 cu. ft. of oxygen at 130 lbs. per sq. in. and 12 cu. ft. of acetylene.—*American Machinist.*

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Copies to paid subscribers	2,731
Copies to advertisers	85
Copies to prospective advertisers	75
Copies to other trade papers, correspondents, etc	60
Copies mailed as samples to prospective subscribers	1,139
Copies for office use	10
TOTAL	4,100

VOLUME 2. MAY, 1917 NUMBER 5.

Buy A Bond.

EVERY true and loyal citizen has a duty to perform during the war. If it is impossible for you to enlist, cultivate a garden or buy a Liberty bond. Bonds may be had in denominations as low as $50 and your local bank will make it easy for you to buy. Don't "let George do it all."

Welders for the Army.

IN the April issue of *The Welding Engineer* we suggested that welders who are willing to serve their country, in the army, navy or munition plants, communicate with *The Welding Engineer*. We have had a great many communications in answer to our editorial and on behalf of the welding industry we wish to thank the patriotic gentlemen who wrote us. So far as we are able to learn, welders have not been graded by the army or navy, as have other mechanics. We have no doubt this will be done shortly and as soon as *The Welding Engineer* is in possession of any information on this subject our readers will be advised.

A Tax That Would Cripple.

A GLARING injustice of the revenue bill reported to the House of Representatives last week is that which increases the postage rates on newspapers and periodicals by three to five times what is now paid. Publishers throughout the country have said with one voice that the proposal of the zone system with the increases it entails is unreasonable, and would amount in many cases to practical confiscation. It was brought out at the hearing at Washington before the Senate Finance Committee on Monday that if these increases go into effect many publications will be compelled to suspend.

The effort to establish the zone system for newspapers, putting them in the same class with miscellaneous merchandise carried by parcel post, was defeated in the last Congress. It is now brought forward as a part of the war revenue program, and with no regard for the merits of the question an effort is made to crowd it through as a war necessity, to be voted for with eyes shut, as the chairman of the committee put it.

Hints For the Welder

WELDING TABLE.

I am sending you a drawing of an aluminum preheating rack. The table of angle iron is fastened firmly to the floor. The three shorter bars are placed on top of the two longer ones and all bars may be moved in any desired position so as to accommodate any type crank case. Now place crank case on three bars, one bar in middle, one at each end. Be sure crank case is blocked up evenly so as not to have its weight on one part. Now cover entire case with three or four sheets of asbestos and light both gas burners. It requires about 1½ to 2 hours to heat up the average crank case. Now my method of welding a crank case or this rack is to see that it is properly aligned before I place it on preheating rack. This done I often put bars through crank shaft leaving it break in close to crank shaft bearings. Then put on preheating rack until hot enough to weld. I do not bevel out crack before but do it with puddle stick as I weld. I do not move case during welding or until cool, but it is necessary to weld bottom cracks and inside lying on a creeper. This method I use only on the most difficult breaks.

This method of preheating is certain. It leaves no strain and there is no danger of case warping or being under strain, but it does require more skill to make a solid weld in this manner.

E. J. Frank.

QUESTIONS AND ANSWERS.

Editor: I have welded small pieces of Stellite to machine steel shanks, and have had fair success with them. I use ⅛ vanadium steel rod and silicate of soda for a flux, and cool same off with a jet of compressed air. I also have been making heavy duty tools, using Rex A. A. high speed steel. My welds appear O. K. when tool is dressed off. I have even put them under a glass and could not detect a flaw. When these tools are hardened by the blacksmith they show checks between the H. S. steel and edge of weld (vanadium steel used), and also sometimes between weld and machine steel. The blacksmith uses the following method of hardening; he heats the tool to a cherry red in the forge and then plunges it into a tank of quenching oil. I do not know what the ingredients of this oil are, but I know it is not fish oil. I use a slightly excess acetylene flame and confine it as much as possible to the machine steel, so as not to burn the H. S. steel. Can you point out my mistake?

George F. Walker.

Answer: You have used the right rod and flux. For hardening purposes use American or fish oil, but do not cool them with a jet of compressed air. High speed steel does not expand as does the low carbon steel and you are therefore inviting internal strains right at the end of the weld. As I understand it you are welding the low carbon steel to the high speed steel or Stellite direct, without any preliminary operation. You would be more successful if you build on about ⅛" vanadium steel on the high speed steel or Stellite. Meantime have tool holders (l. c. steel) preheated to a cherry red and then weld the high speed steel, with its vanadium surface, to the l. c. steel. It is not necessary to use an excess of acetylene in your flame, but use a neutral flame and confine it as much as possible to the l. c. steel. On page 23, June, 1916, *The Welding Engineer*, an article was published on this subject.

Editor.

WELDED BUOYS.

Editor: I am enclosing a sketch of a buoy. We are making 600, one man welds four buoys in eight hours. Their

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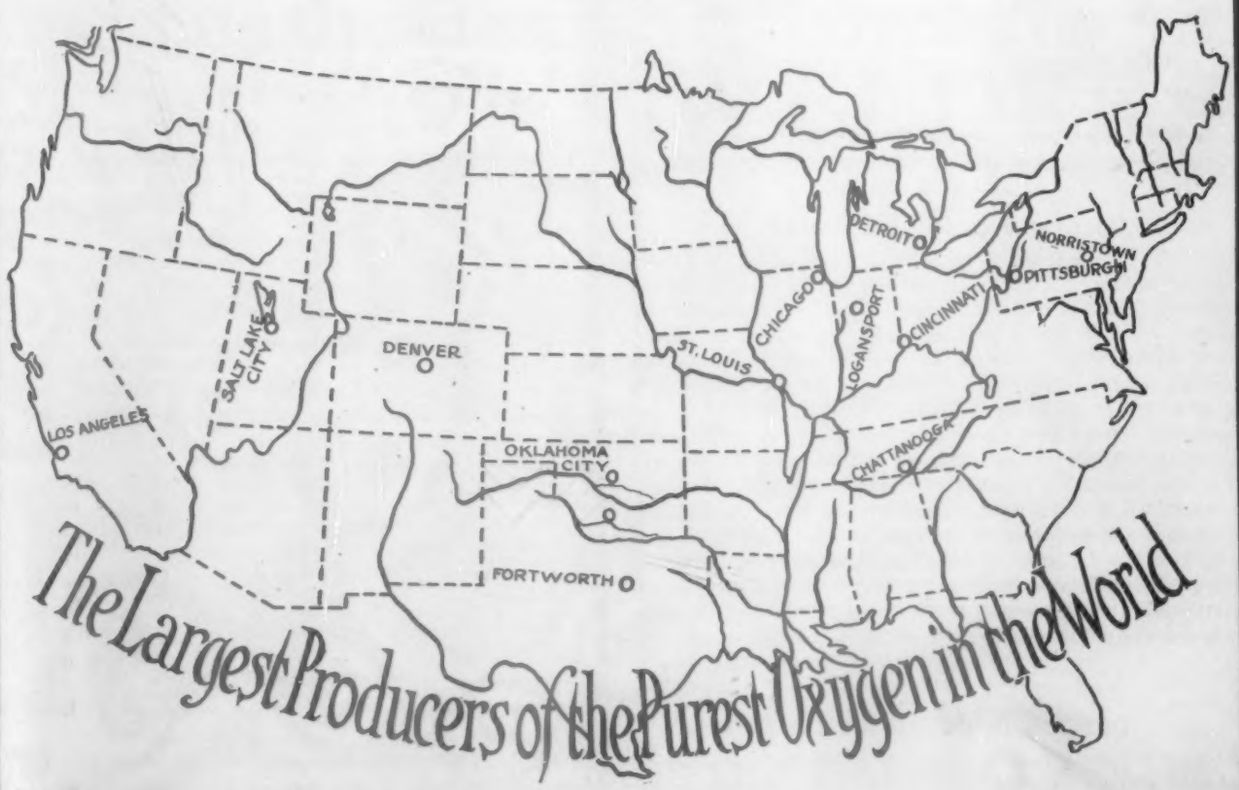


The Largest Producers of the Purest Oxygen in the World

heads are pressed from ⅛" sheet steel. A seating is welded in each end to relieve the air, also to use in testing, 60 pounds per square inch is required, but we have tried 100 pounds, with good results.

J. A. Stewart.

WAGES FOR LEAD BURNERS.

Editor: Please give information as to wages paid lead burners in various parts of the United States.

S. H. R.

Answer: A large manufacturer employing this class of help, in various parts of the country says: "We are not familiar with the wages paid lead burners except at our own plant and various branches throughout the country where we maintain battery service stations.

"We do not as a rule employ experienced lead burners but prefer to train our own men in handling this work with the oxy-acetylene blow-pipe and these men are paid from 25 to 35 cents per hour, according to their skill.

"We have found that it is easier to train a new man than to convert an oxy-hydrogen lead burner to an efficient oxy-acetylene lead burner, because they have been trained in handling the less intense flame heat and seem to find it more difficult in handling the hotter flame than the new man would, who has never been accustomed to handling a flame. Occasionally, however, we find experienced lead burners who immediately grasp the situation and become even more expert and enthusiastic at once over the greater speed obtainable and smoother joints possible by the oxy-acetylene process."

Editor.

BRAZING CAST IRON.

Editor: Seeing something about brazing cast iron, I am sending you a formula for this kind of work and if it is used right can braze any kind of cast iron or castings and any mechanic can make it in a few minutes.

Powdered malleable cast filings and powdered borax, equal parts mixed. Add liquid water and borax. Heat parts red and sprinkle some along crack and above to sweat into crack, then heat up and use ⅛" spelter wire. Clean all burnt and grease from castings and rivet or bind or clamp broken parts together. This I have used for twenty years or more.

Wm. D. Croutner.

OIL AND GASOLINE TANKS.

Editor: We welded a crack in a tank which had been emptied 24 hours. Then we ran hot water into same and flushed it out. We had no trouble and made a good job. Another crack in the largest compartment showed up yesterday and the driver of truck said he emptied the tank this morning. About 2 p. m. we filled compartment ⅔ full of water and ran truck around streets drained water out and started to weld. The filling cap was of about 4" diameter and there was an explosion "good and plenty," a noise like a cannon, bursting a number of seams and bulging the compartment we were to weld. I am writing this as a warning to welders not to listen to the request, "we have to have it right away." Be sure to drain gasoline and oil. I would advise waiting two or three days, then flush out with water, overflowing at filling hole. Concerning prices, we charge 50 cents for our minimum job, and of course on up.

Greenwalt & Son.

DANGER IN CUTTING TANKS.

Editor: We have had several explosions in St. Louis of tanks or containers that were either being welded or cut up. In every instance these tanks were being worked on by scrap yard people, and after the explosion were found to have contained paint, acid or oil.

Several people have been killed and others injured and I desire to call your attention to this with the suggestion that it might be well for you to, in turn, call the attention to your readers, to the fact that all tanks or containers that operators may have occasion to work on, should be thoroughly examined and their previous contents determined before starting work. If they have contained oils, paints, acids, etc., precautions must be taken for cleaning them thoroughly.

P. F. Willis, President.
Henderson-Willis Welding & Cutting Co., St. Louis, Mo.

CAST IRON DIFFICULTIES.

Editor: I am sending a diagram of a cast plate that I tried to weld. I preheated the plate and welded between the ribs while in the furnace and then I turned it on edge to weld the ribs and got one rib welded and it cracked all the way across. The ribs are three inches high and one-half to one and one-quarter inches thick.

To weld a seam vertically, should I use carbon blocks. I would like some information regarding this job. I used charcoal to preheat. The top of the plate is one and one-quarter inches thick, besides the ribs on the bottom.

R. Simpson.

Answer: It is possible to use carbon blocks in a job of this character to build up the ribs but we hardly think it is necessary. Evidently your trouble was due to the fact that after making the weld while the casting was at a proper heat, you attempted to again heat a section by welding the rib and the plate very properly cracked, as you were setting up a strain in one section without taking care of it by heating it in the fire the entire section affected as you properly did when you welded the main break.

Work of this charactter should be preheated to a dull red and welded while in the fire, holding the entire line of welding at this heat while the weld is being made. Inasmuch as these ribs are probably there for strength and not for accurate machine work, they may be built up roughly while the weld is being made and without the use of carbon blocks.

Editor.

ANALYSIS OF CAST IRON.

Editor: Kindly advise us the typical analysis of cast iron welding rods.

Vestern Welding Mfg. Co.

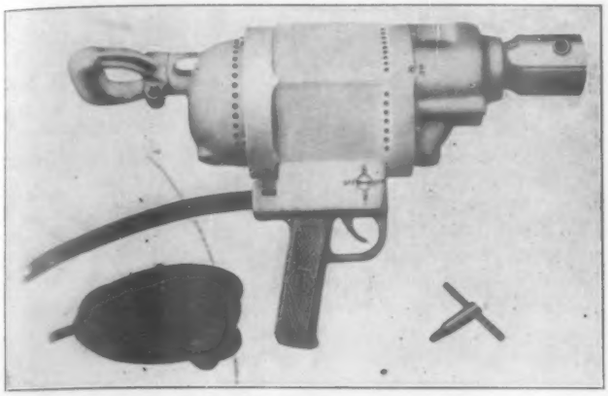
Answer: We referred this question to Bierman-Everett Foundry Co., specialists in the manufacture of cast iron welding rods. They advise as follows:

"We give you the usual analysis of cast iron welding rods. You will understand, of course, that this mixture varies sometimes, but we try to keep same running as near uniform as possible. Then again, some concerns prefer a somewhat different mixture, which we are always glad to furnish. But the analysis as given is, in our opinion, the best for all around work."

Silicon	3 to 3½	per cent.
Combined carbon, not over	.2	per cent.
Phosphorus, not over	.1	per cent.
Sulphur	.5	
Manganese	.5	

A CORRECTION.

The April issue of *The Welding Engineer* contained an article on the subject of welding in refrigerating plants, written by Mr. M. Keith Dunham. Credit should have been given our esteemed contemporary, *The Refrigerating World*, from whose columns the article was reprinted, by permission.



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It will be seen, by reference to the illustrations, that the control is that of the automatic pistol, one finger doing the work without in the slightest affecting the steadiness of the aim or the firmness of the support of the tool. There is no releasing of the grip to turn the switch or press a button, or push in or pull out a handle at the moment the drill breaks through.

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THE WELDING ENGINEER, 608 S. Dearborn St., CHICAGO

Hints To WELDERS

Can you write intelligently about the welding work you do, or which is done under your supervision? That is to say, when you finish an interesting piece of work, can you set down on paper the manner in which you went about the job, how you prepared the work, how you preheated and how the job was done? Have you learned in the hard school of experience some little stunt which every welder ought to know? If you can answer yes to the above questions you are the man I am looking for. I'll pay you a fair price for that bit of experience and I'll print it in The Welding Engineer "Hints to Welders" where more than 4,000 of your fellows will see it. Write it down any old way—I'll polish it up. Make a rough pencil sketch and our draughtsman will fix it up fine. Line drawings are more practical than photographs. Do it today—the men on the firing line are waiting.

L. B. MACKENZIE, Editor

The Welding Engineer

608 S. Dearborn St., : Chicago

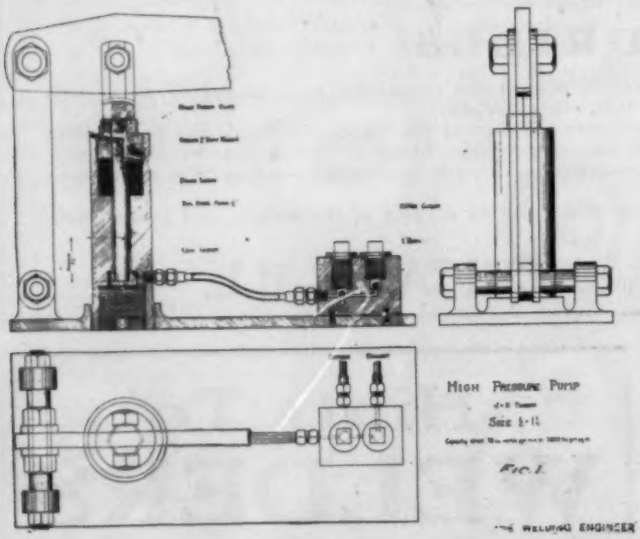
EFFICIENCY OF WELDED PIPE.

During the early part of last year there was published in *The Welding Engineer* a report of a series of tests conducted by Professor F. H. Sibley, of the University of Kansas, to determine the relative strength of welded and screwed pipe connections. Owing to their exhaustive character and disinterested source, the results of these tests were found very interesting.

Professor Sibley has now completed a further series of tests to determine the relative efficiency of welded and screwed pipe connections under tension. Since there is at the present time a very real and wide spread interest in the subject of oxy-acetylene welding for pressure systems, we believe readers of *The Welding Engineer* will be interested in learning the results of these tests and the means of making them. Professor Sibley's report follows:

Hydraulic Pressure Tests of Oxy-Acetylene Welded and Screwed Pipe Connections.

The interest created by an article that appeared about a year ago giving a report of tests of oxy-acetylene welded pipe connections and screwed pipe connections tested under



Hydraulic Pressure Pump Used for Testing Welded Connections

tension and compression, and the desire of readers for further information regarding the relative strength of welded and screwed pipe connections, encouraged the experimenters* to carry on a second series of tests.

These tests were conducted in the machine construction laboratory of the University of Kansas and had for their purpose the determination of the relative strength of welded and screwed connections in steel pipe of various sizes when subjected to internal hydraulic pressure.

The pipe samples, which were cut from standard black steel pipe, were from the same stock and hence probably of uniform quality. The welded specimens were made by operators of the Oxweld Acetylene Co., Chicago. The screwed connections were made up with malleable iron couplings and tees by expert pipe fitters. The pieces for the butt welds were cut at an angle of about 60 degrees in a pipe cutting machine to get the necessary "V" groove for welding. The "T" welds were made by cutting a hole in the run and butting the outlet against the run. The ends of all the specimens were sealed by welding in plugs or disks made from boiler plate punchings. Two of these disks are shown at the bottom of Fig. 3.

The specimens were subjected to pressure by means of a small hydraulic pressure pump, Fig. 1, which was made especially for this work. The specimen under test was placed about 25 feet from the pump and connected to it by means of a ½-inch copper tube. A pressure gauge with a check valve opening toward the gauge was placed between the pump and the specimen. The check valve was necessary to steady the pressure in order that satisfactory readings could be obtained because some of the samples carried pressures greater than 5,000 pounds per square inch before failing.

The illustrations show several of the specimens tested and their modes of failure.

Welded 2 and 3-inch specimens are shown in Fig. 2. These failed by splitting along the longitudinal seams of the pipe, the split stopping at the welded section. The 4-inch welded specimens in Fig. 3 bulged under the high pressure, but did not fail in either the weld or the pipe seam.

The mode of failure of two of the screwed connections are shown in Fig. 4. The bursting pressures for the screwed connections were way below that of the welded specimens and all failed in the fitting. Great difficulty was experienced in testing the specimens made up with screwed fittings because sand holes developed and the water leaked through the castings to such an extent that it was almost impossible to reach the point of rupture. Fig. 5 shows one of the screwed "T" specimens under test and illustrates clearly the leaky condition just mentioned.

Examination of the data given in the table shows that in only one case was there failure in the weld and that was merely a leak which did not develop until 3,850 pounds per square inch pressure was applied. This brings out the point that while leaks are much less likely to occur in welded than in screwed connections they are the principal cause of difficulty. Therefore, pipe lines that are to be subjected to high pressure, if properly tested for leaks when installed, should give no trouble under service.

The results of these tests bear out the conclusions given in the previous series, namely:

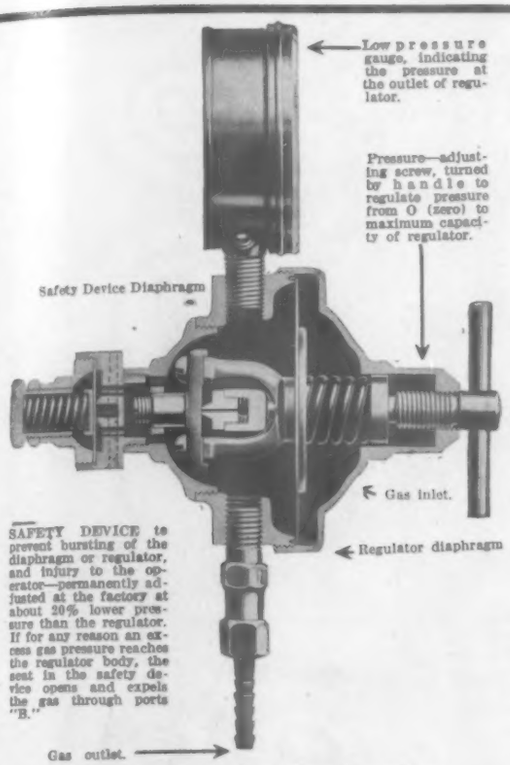
a—The strength of a welded pipe connection is practically the same as that of unwelded pipe. By slightly building up the weld it can be made stronger than the rest of the pipe.

b—The strength of the welded pipe connection is very much greater than that of the malleable iron screwed fittings.

c—Although a careless or inexperienced operator might produce a leaky joint, nevertheless, if the pipe line is tested for leaks when installed it should give no difficulty in service.

Hydraulic Pressure Test of Oxy-Acetylene and Screwed Pipe Connections.

Size Pipe In.	Type Joint	Pressure at Failure Lb. per Sq. In.	Maximum Pressure Lb. per Sq. In.	Nature of Failure	Condition of Weld
2	Welded "T"	4400	4400	Tube seam split	O. K.
2	Welded "T"	2200	2200	Leak in tube seam	O. K.
2	Welded "T"	4750	4750	Tube seam split	O. K.
2	Screwed "T"	2350	2750	Sand holes in fitting	.....
2	Screwed "T"	500	2000	Sand holes in fitting	.....
3	Butt Weld	.....	5300		O. K.
3	Butt Weld	4950	4950	Tube seam split	O. K.
3	Butt Weld	.....	4250		O. K.
3	Coupling	3950	3950	Coupling split	.....
3	Coupling	3400	4400	Leak in coupling	.....
3	Welded "T"	.....	3500		O. K.
3	Welded "T"	.....	4250		O. K.
3	Welded "T"	.....	3505		O. K.
3	Screwed "T"	350	2700	Sand holes in fitting	.....
3	Screwed "T"	300	3100	Sand holes in fitting	.....
4	Butt Weld	.....	5100	Pipe bulged	O. K.
4	Butt Weld	.....	3250		O. K.


Low pressure gauge, indicating the pressure at the outlet of regulator.
Pressure—adjusting screw, turned by handle to regulate pressure from O (zero) to maximum capacity of regulator.
Safety Device Diaphragm
Gas Inlet.
Regulator diaphragm
SAFETY DEVICE to prevent bursting of the diaphragm or regulator, and injury to the operator—permanently adjusted at the factory at about 20% lower pressure than the regulator. If for any reason an excess gas pressure reaches the regulator body, the seat in the safety device opens and expels the gas through ports "B."
Gas outlet.

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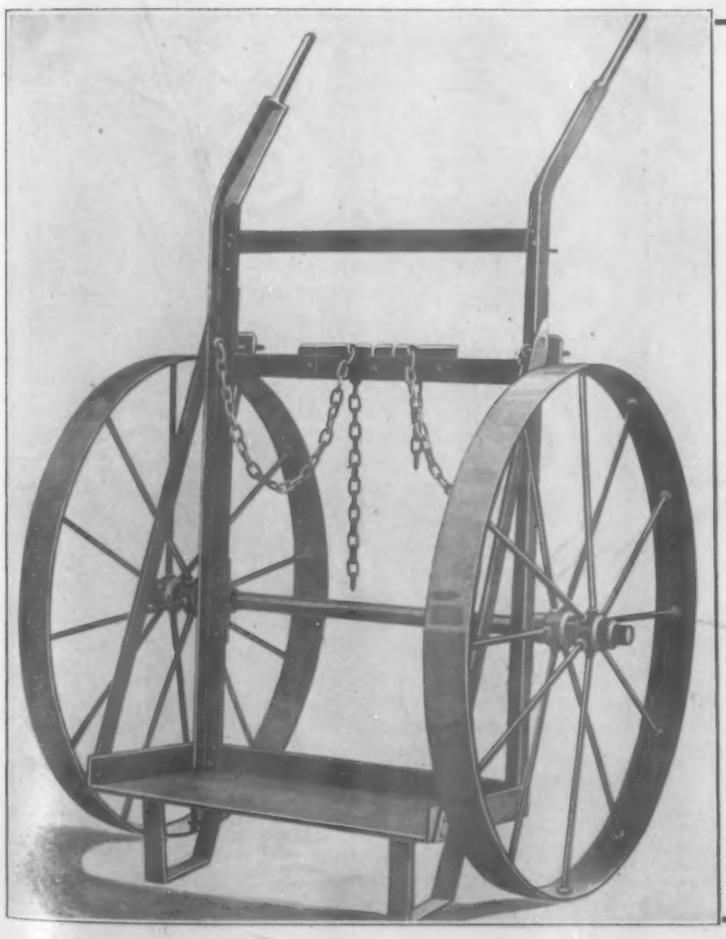

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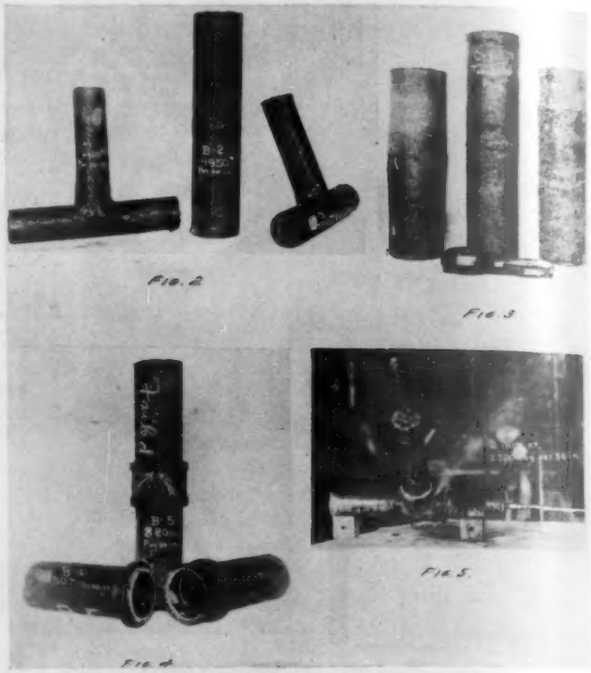
4	Coupling	300	3000	Leak at threads	.....
4	Coupling	750	2600	Leak at threads	.....
4	Welded "T"	3850	5100	Leak in weld	Leaked
4	Screwed "T"	1000	1950	Sand holes in fitting	.....



Welded and Screwed Pipe Connections

The colleges and technical schools are grinding out hopeful young mechanics and engineers in great numbers. Many of these young men find it difficult to select some particular branch of engineering in which to specialize. We suggest that the subject of welding engineering offers many advantages to the young engineer. The field is in its infancy and is growing rapidly. Skilled specialists, promising technical training, are badly needed in the welding industry.

**F. H. Sibley, Professor of Mechanical Engineering, University of Kansas, assisted by Messrs. Maris, Ruth, Schooley, Jesperson and Dryden.*

FLAME STRUCTURE AND ITS RELATION TO WELDING.

By F. E. Totten.

Too often the average welder and sometimes the more advanced welder has no idea of the structure of the flame and the effects it is capable of producing in a weld. This structure I am about to describe is true of any gas flame, whether it be a candle flame, an oil lamp flame, or an oxy-acetylene flame.

Let us observe for instance the flame of an ordinary tallow candle or a gas jet. It is seen to consist of three distinct cones as O-N-R.

The cone designated by the letter R is much darker than N or O and consists of the unburned gases in the flame. These gases, usually hydro-carbons, are passing upwards to the point N where complete combustion takes place. The presence of the unburned gases in the cone R can be proven by bending a small glass tube in the manner shown and inserting it in the middle of the cone R.

If a lighted match be held at the drawn end of the tube L a small gas jet will be formed, proving conclusively that the cone R is composed of the gases that have not been heated to their combustion point and therefore have not gone into combination with oxygen to form carbon-dioxide and water.

At the point N the gases, etc., in the cone R have passed to a higher point and having their temperature raised at the

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same time have reached their ignition point and combine with the oxygen of the air, resulting in their combustion to carbon-dioxide or water, or both, as the case may be. This is the point at N of highest temperature and all heating should be done at this point.

The letter O in Fig. 1 represents the larger and enveloping cone which entirely surrounds the other two cones, extending some distance above it. At this point there is an excess of the oxygen actually required to produce complete combustion, resulting in an oxidizing flame. A piece of steel held in this outer cone will, when red hot, commence to check and scale, showing the combination of the oxygen with the steel.

A piece of steel held at point N of Figs. 1 and 2 will be heated rapidly but will not scale as it did in the preceding paragraph, because the oxygen entering the flame at this point is consumed in the combustion of the gases rising from cone R.

If a piece of steel is held in the cone R it will heat much more slowly and may even have a black sooty coat deposited on it. This coat is unburned carbon.

Carbon and hydrogen, the principal constituents of cone R, are among the best reducing agents; that is they are capable of bringing a substance from a higher to a lower state of oxidation by combining with the oxygen of the substance they come in contact with and removing a portion of it.

Fig. 1

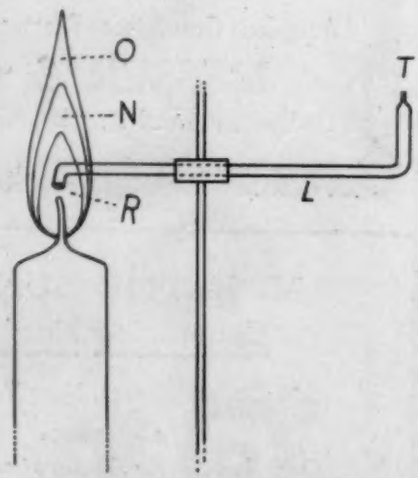

Fig. 2

Chemists, when they wish to reduce the oxygen content of an oxide or compound with oxygen, accomplish it by holding the substance in the carbonizing or reducing portion of the flame of a Bunsen burner and heating it. When they only desire to heat a substance they hold it at point N, Figs. 1 and 2.

When they wish to oxidize a substance they hold it in the larger outer cone, which is very hot and contains an excess of oxygen, oxidizing the substance held in it very rapidly.

Now as to the relation of the neutral flame of an oxy-acetylene torch to successful welding. A neutral flame possesses the three cones just described in the candle flame.

When the small cone of the neutral flame, which corresponds to N of the candle flame, is held just above the work to be welded it is neutral in its action, neither carbonizing nor oxidizing, simply heating, whch s just what is desired.

When the oxy-acetylene flame is pressed down enough to flatten it on the work being welded, which is identical in effect to inserting in the reducing or carbonizing flame of R, Fig. 1, the unburned carbon of the acetylene goes into combination with the metal, say a piece of steel or cast iron, resulting in an unsatisfactory weld. This is almost as rapid a method of carbonizing a piece of steel as by h ing an excess of acetylene in the flame.

If a piece of metal is held at the extreme end o e pre-heating flame, that is the large flame extending be nd the small white cone, it will be rapidly oxidized whi is at-tested by scaling of the surface.

In the above paragraph we have not taken into acc nt the hydrogen issuing from the blowpipe with the carb of the acetylene. Acetylene is composed of carbon and h drogen according to the formula C_2H_2, which hydrogen ing to the high temperature of the flame cannot comb with oxygen to form water, and so surrounds the flame nd the metal of the immediate weld, protecting it from the idizing action of atmospheric oxygen. However, at the xtreme end of the flame the hydrogen ceases to act as a sh ld and metals held at that point are rapidly oxidized.

It is hoped the reader will be able to more thoroughly understand the structure of a flame after a careful perusal of the above and apply the information gained to producing a better class of welding.

Members of the Chicago Brass Manufacturers' Association have offered their plants to the government. Among members known in the welding trade are Bastian-Blessing Co., Federal Brass Works and Imperial Brass Mfg. Co.

WELDING A PUMP

Editor: This job may interest your readers. The pieces were lost, so I filled in, which I did with a piece of old wagon boxing. This job belongs to a pump of a tug. I preheated in an old box stove, the kind without bolts. I used hard wood and put the pump head on top. When good and hot I welded one part, turned it over and welded the other side through the door of the stove. Then I built another fire and allowed the job to cool. I use the old stove a great deal for preheating. W. E. Rodgers.

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Wanted—First-class oxy-acetylene welder for all kinds of jobbing work, mostly broken coal mining machinery, such as gears, mine locomotive castings, etc., in cast iron, steel and brass. Must be especially good on heavy, intricate machine work. Man with blacksmith, boilermaking or machinist experience preferred. Steady employment at such work when not otherwise engaged. State age, pay expected and furnish best of references as to capability and habits. Address Egyptian Iron Works, Murphysboro, Ill.

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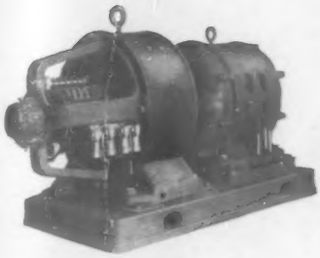

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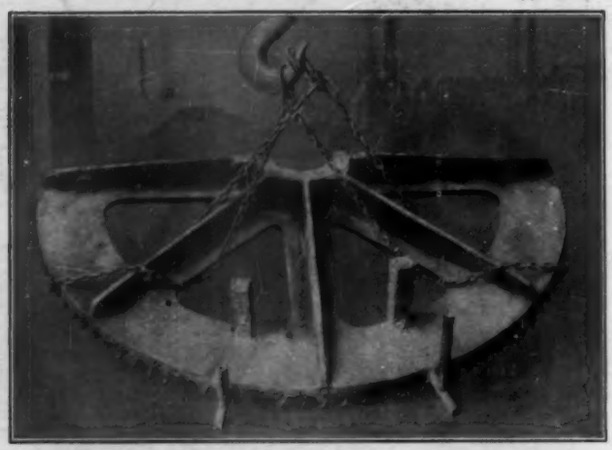

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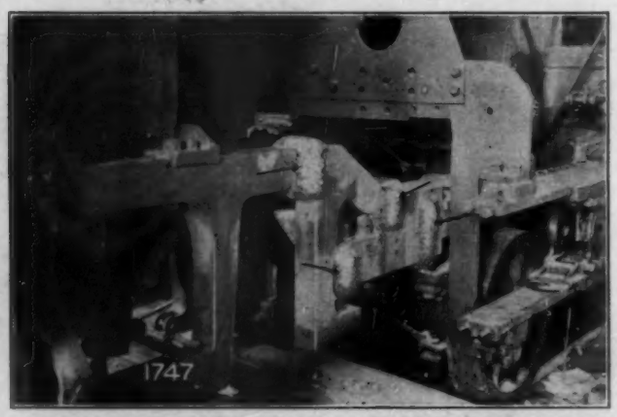
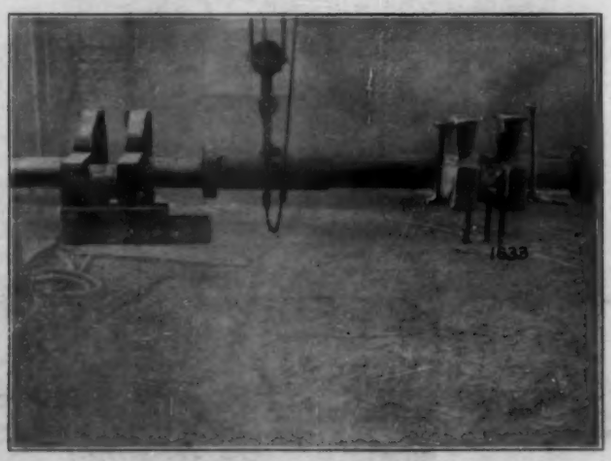


Four Thermit welds on locomotive frame on the Missouri Pacific Railroad, made without removing the frame from place.



New crank pin welded in by the Thermit Process.

Thermit Does the Heavy Welding and Does It Right

The Thermit Welding Process is the only one that is best adapted to repairing of heavy sections (see illustrations).

Thermit will repair such sections quickly and economically. Many serious delays have been avoided from the use of Thermit Welding and saved thousands of dollars in time and expense.

If you have a breakdown

wire or telephone our nearest office and we will proceed at once for arranging the shipment of materials and send an expert to supervise the repair.

We have an eighty-page pamphlet devoted exclusively to this class of work, which is known as pamphlet No. 1779, and tells how the work is executed and how you can do the work yourselves.

Goldschmidt Thermit Co.

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New York

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103 Richmond Street, W., Toronto, Ont.